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THESIS

EXTENDED MAGTF OPERATIONS – TACTICAL CHAT

by

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March 2017

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The relatively new MV-22 Osprey has significantly extended the range Marine Air-Ground Task Force (MAGTF) forces can deploy under the cover of a single period of darkness. Unfortunately, this extended range has strained the effectiveness and reliability of the MAGTF's communications capabilities. The purpose of this thesis is to provide a proof of concept for an economical, easily manufactured, reliable, low bandwidth, communications system capable of passing data over hundreds of kilometers through vertical terrain. In the course of this study, a successful communications system is created, utilizing COTS radios and hardware to circumvent vertical obstructions. Digital text messages are successfully transmitted through an analog radio signal over a distance of 170 miles. The transmissions pass through a relay radio attached to a high-altitude balloon. The system proves sufficiently speedy and reliable despite utilizing disparate end-point radios. This thesis successfully demonstrates the potential this system has to extend United States Marine Corps communications. Further research should focus on the system's capability over a larger range and the effects of system configuration settings on transmission speed and reliability.

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EXTENDED MAGTF OPERATIONS – TACTICAL CHAT

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ABSTRACT

The relatively new MV-22 Osprey has significantly extended the range Marine Air-Ground Task Force (MAGTF) forces can deploy under the cover of a single period of darkness. Unfortunately, this extended range has strained the effectiveness and reliability of the MAGTF's communications capabilities. The purpose of this thesis is to provide a proof of concept for an economical, easily manufactured, reliable, low bandwidth, communications system capable of passing data over hundreds of kilometers through vertical terrain. In the course of this study, a successful communications system is created, utilizing COTS radios and hardware to circumvent vertical obstructions. Digital text messages are successfully transmitted through an analog radio signal over a distance of 170 miles. The transmissions pass through a relay radio attached to a high-altitude balloon. The system proves sufficiently speedy and reliable despite utilizing disparate end-point radios. This thesis successfully demonstrates the potential this system has to extend United States Marine Corps communications. Further research should focus on the system's capability over a larger range and the effects of system configuration settings on transmission speed and reliability.

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LIST OF ACRONYMS AND ABBREVIATIONS

ALE	automatic link establishment
AOR	area of responsibility
ASCII	American Standard Code for Information Interchange
C2	command and control
COTS	commercial off-the-shelf
DOD	Department of Defense
EPLRS	Enhanced Position Location Reporting System
FSO	free space optics
GPS	Global Positioning System
GTRS	Gemensamt Taktiskt Radiosystem
HAB	high altitude balloon
HFMR	high frequency man-pack radio
JTRS	Joint Tactical Radio System
LOS	line of sight
MAGTF	Marine Air-Ground Task Force
MBITR	multiband inter/intra-team radio
ONR	Office of Naval Research
OTH	over the horizon
RF	radio frequency
SDC	Space Data Corporation
SINCGARS	Single Channel Ground and Airborne Radio System
SRW	soldier relay waveform
UAV	unmanned aerial vehicle
USAF	United States Air Force
USMC	United States Marine Corps
VDC	ViaSat Data Controller
Vmail	ViaSat eMail
WNW	wideband networking waveform

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I. INTRODUCTION

A. BACKGROUND

Recent operations in the war on terror have demonstrated the value of precision deployments and strikes made at long ranges from operational headquarters. Long-range United States Marine Corps (USMC) deployments are particularly common given the expeditionary nature of its mission. The relatively new MV-22 Osprey has significantly extended the range Marine Air-Ground Task Force (MAGTF) forces can deploy under the cover of a single period of darkness. Unfortunately, the extended range of operations has strained the effectiveness and reliability of the MAGTF's communications capabilities creating conflicts with maintaining command and control on the battlefield. This thesis outlines the problem, identifies the purpose of the intended technology, provides a background of the technology studied, identifies study methodology, provides study results, and draws conclusions based on the results.

B. PROBLEM STATEMENT

The problem is that current communications capabilities do not adequately support command and control requirements for long-range USMC operations. Current operations often exceed the range of the communications systems employed. Additionally, the mountainous terrain of the modern battlefield further degrades the communication system's effectiveness and reliability. The interruptions in communications pose vital risks to MAGTF personnel and mission success. To mitigate these risks, research is warranted to validate the feasibility of establishing and to maintain long-range communications.

C. PURPOSE STATEMENT

The purpose of this study is to provide a concept demonstrator for a communications system that can provide reliable low bandwidth data communications over ranges up to 700 miles. To provide an economic and easily manufactured solution, the components will consist of Commercial-Off-The-Shelf (COTS) equipment. This study identifies the capabilities of the system as assembled and provides a recommendation to the viability of the system in meeting current MAGTF needs.

D. RESEARCH QUESTIONS

- How can an existing USMC system be adapted or augmented to provide a low cost low bandwidth two-way data connection capable of circumventing vertical obstructions?
- Over what ranges might such a system maintain connectivity?

E. ORGANIZATION OF THESIS

This thesis is organized in the following manner.

- **Chapter I** Introduction – provides a brief description of the background, the problem, the purpose, scope, research questions, and organization of the study.
- **Chapter II** Literature Review – provides a comprehensive background of the current capabilities relating to the study as well as phenomena associated with transmission mediums and communications platforms.
- **Chapter III** Methodology – provides the methodology used to design the system, a description of the designed system, and the procedures designed to evaluate the chosen system.
- **Chapter IV** Results – provides the data and observations gathered during the system evaluation as well as an analysis of the results.
- **Chapter V** Conclusions and Recommendations – provides conclusions pertinent to the USMC based on the results as well as recommendations to the USMC on future areas of study.

II. LITERATURE REVIEW

A. CURRENT/PROSPECTIVE MILITARY CAPABILITIES

The United States Marine Corps learned the challenges of maintaining data connectivity for its operational forces during Operations Desert Storm, Enduring Freedom, and Iraqi Freedom (Guice & Munoz, 2004). These challenges are exacerbated by the increasing distance between the major subordinate commands and the maneuvering forces as well as the geographic terrain of the urban Iraqi and rural Afghani areas (Guice & Munoz, 2004). When analyzing potential solutions to these problems, currently employed systems were first considered. The USMC utilizes several communication systems; among which, several could provide a means for passing digital data.

1. Terrestrial-based Radio Systems

The United States military currently employs a multitude of radio systems with variances based on intended use, propagation characteristics, geographical footprint, size, etc. Radio technology has existed for decades and as a result is a stable technology throughout the world and within the military. The historical uses of radio within the military have centered on maintaining command and control through voice communications but, with recent advances in radio technology, it has started serving as the medium for data connections. Despite being an older and more stable technology, radio propagation is susceptible to *shadowing* (signal degradation caused by environmental obstructions).

a. Enhanced Position Location Reporting System

The Enhanced Position Location Reporting System (EPLRS) was originally designed to provide battlefield commanders with positioning data for their maneuvering forces via digital data passed over radio waveforms (Bey, 2005). After the Global Positioning System (GPS) became stable and more prominent, the EPLRS was less utilized toward providing a means to maintain positional awareness of assets and instead, through several refits and upgrades, shifted focus to providing a data routing capability throughout a radio network (Bey, 2005).

The EPLRS has a multitude of benefits as a potential solution. The system can support up to 488 kilobits per second (Kbps), can utilize several multiple access protocols, utilizes embedded security, is already in use, and can establish connectivity with other employed data systems (Bey, 2005). Unfortunately, the EPLRS has a range limitation of approximately 100 kilometers (km) for ground to air communications (Bey, 2005). This solution requires multiple communications relays causing network congestion, potential interference problems, and requires the deployment of nodes over enemy territory (Bey, 2005).

b. High Frequency Man-pack Radio

The High-Frequency Man-pack Radio (HFMR) is capable of passing data over the horizon (OTH) to maneuvering units (Bey, 2005). Data rates for unsecure communications are 9600 bits per second (bps) while secure communications pass at 2400 bps (Bey, 2005). The system is capable of passing data through point-to-point (PTP) connections (Bey, 2005). The HFMR is type 1 certified by the National Security Agency and comes with an Automatic Link Establishment (ALE) feature (Bey, 2005). ALE is s method of establishing and maintaining digital connections over high frequency radio communications through the typical variances in signal strength caused by normal environmental degradation. While the HFMR can provide the desired range and throughput, it does not provide an answer to shadowing caused by the tall horizontal obstructions of a rural or mountainous environment.

c. Single Channel Ground and Airborne Radio System

The Single Channel Ground and Airborne Radio System (SINCGARS) is a suite of radios that serve as the primary means of communication for command and control (C2) and fire support on the battlefield (United States Marine Corps [USMC], 1988). Widely used since the 1980s, the system boasts a high security posture against electronic warfare via frequency hopping and is capable of voice and data transmissions of up to 16Kbps under optimal conditions (Congressional Budget Office [CBO], 2003). The primary drawback of SINCGARS is its range. The radio, typically carried by infantrymen, only has a range of 8km and the vehicle-mounted variant is only capable of a 35km range (USMC, 1988).

d. Joint Tactical Radio System

The Joint Tactical Radio System (JTRS) was supposed to consolidate several legacy radio systems into one system that could provide portable, interoperable, and mobile ad hoc networking via software-defined waveforms for Joint Operations (Swick, 2006). For JTRS, the employed waveform defines the capabilities of the radio; therefore, this section will delve into several waveforms envisioned in the JTRS suite, which could provide the desired capability (Maxén, 2011).

One waveform of significance to this study is the Wideband Networking Waveform (WNW). The WNW is intended to support a 6.2-mile range with data rates of 5 megabits per sec and provide mesh capabilities (Swick, 2006). The purpose of the mesh capability is to provide a self-forming and self-healing communication medium capable of meeting the wireless, mobile, and security demands of modern military operations (Swick, 2006). Currently, the WNW is still under development (Department of Defense [DOD], 2015). While the WNW would meet MAGTF's bandwidth needs, the range does not warrant serious consideration for the extended operations this thesis is analyzing.

The Soldier Radio Waveform (SRW) is intended to be used by infantryman and is meant to provide network communication between large numbers of geographically dispersed nodes (Maxén, 2011). In a test of the waveform, 36 radios were able to maintain communications in a battlefield environment (Maxén, 2011). The SRW is a self-healing network utilizing code division multiple access (CDMA) to maintain communication between nodes in the presence of link drops and signal losses (Maxén, 2011). The SRW can achieve data rates between 450 Kbps and 1.2 megabits per second (Mbps). It also has modes for the security of the transmitted communications but the data rates drop to between 2 Kbps and 23.4 Kbps (Maxén, 2011). Currently, the SRW is partially fielded with just under 20,000 Rifleman Radios fielded (DOD, 2015).

Throughout its development, JTRS has had several restructurings caused by significant schedule, cost, and performance setbacks (Maxén, 2011). As a result, the system is still in development; although, various components of the system have been decoupled in an attempt to mitigate risk and provide partial capability to the field before full capability is achieved (DOD, 2015). Consequently, this study will not attempt to incorporate the JTRS waveforms into the analysis.

e. Gemensamt Taktiskt Radiosystem

The Gemensamt Taktiskt Radiosystem (GTRS) is the Swedish sister project to the JTRS (Maxén, 2011). Two notable waveforms associated with this system are the Terrestrial Trunked Radio (TETRA) and Tactical Data Radio System (TDRS) (Maxén, 2011). TETRA is capable of providing a variable data rate of 15.6 Kbps to 538 Kbps within bandwidths ranging from 25 kHz to 150 kHz ((Maxén, 2011)). For the propagation frequencies used, TETRA also has trouble circumventing large vertical obstacles. The TDRS waveform serves as the tactical solution for the system (Maxén, 2011). It is based on a commercial waveform called FlexNet and is capable of providing up to 1 Mbps to 150 nodes over a frequency range of 2–2,000 MHz (Maxén, 2011). The range of TDRS is less than the TETRA waveform and encumbered by large vertical obstacles.

2. Satellite Systems

Satellite communication offers great promise for meeting current and future communications requirements involving capacity and quality (United States Marine Corps, 2012). Satellite communication involves transmission from a ground station to a satellite followed by a retransmission of the satellite to a receiving ground station. The primary benefit of satellite communication is the increased range of communications via the larger line of sight (LOS) created by a satellite’s footprint. Four satellites in geostationary orbit allow for communication from anywhere on Earth between the north and south 70 degree latitude marks (USMC, 2012). Compared to military radio communications, military satellite communications offers larger bandwidth links, higher fidelity, a lack of dependence on reflection or refraction, is minimally affected by atmospheric phenomena, more inherent defense against enemy physical destruction, and a lower probability of detection, interception, and jamming (USMC, 2012).

Despite the aforementioned benefits, the satellite has drawbacks, some of which affect the methodology of this study. USMC satellite communications have larger lead times for usage than traditional radio communications. Lead times for planning channel allotment typically take 45–90 days to process a request (USMC, 2012). While satellite offers larger bandwidth per link, the quantity of links available to U.S. forces is much more limited than radio. As a result, units at the echelon of operations discussed within this study are advised to use satellite communications as a means of last resort because higher priority is given to objectives higher in the chain of command. High cost has a large role in creating the current circumstances around prioritization of satellite links and the lack of more available links. A data connection over satellite costs the military $3,000 a month for 30 gigabytes (GB) of transferred data with additional costs for features such as streaming services, terminal management, firewalls, and a host of other features ("BGAN link – unlimited use BGAN service," n.d., Internet Service section, para.1).

Due to weight restrictions, the only viable source of power for satellites is solar cells (USMC, 2012). Solar cells are highly inefficient forms of power, and therefore, limit the transmission power of the satellite, which in turn, translates to weak transmission signals created by the satellite (USMC, 2012). To compensate for the weak signals and large atmospheric attenuation, the ground station of the receiving end of a satellite communication typically requires larger and more powerful infrastructure. Most of the satellite systems reviewed within this study were disqualified due to size and mobility constraints. The remaining systems, all narrowband systems, were disqualified due to cost, security, and reliability constraints.

3. Free Space Optics

The Office of Naval Research (ONR) is currently developing the Tactical Line-of-Sight Optical Communications Network (TALON) for its Future Naval Capabilities program (Thomas & Moore, 2014). TALON utilizes free space optics (FSO), i.e., lasers, as the medium to pass data over a network (Reynolds, 2013). The system is relatively low cost and provides superior bandwidth as well as enhanced security features compared to traditional radio frequency (RF) communications (Thomas & Moore, 2014). The system can achieve data rates beyond 1 gigabit per second (Gbps) and provides a low probability of intercept, detection, and jamming due to the highly directional laser beams (Thomas & Moore, 2014). An additional benefit of FSO is the completely avoidance of the traditional frequency congestion problem as lasers do not operate within the RF spectrum (Thomas & Moore, 2014). Currently, TALON is capable of providing 100 megabits per second (Mbps) over a distance of 70 km (Thomas & Moore, 2014). FSO would not be a viable solution because currently tall and stable masts are required to act as nodes to achieve the communication distances required by extended MAGTF operations. For these types of missions, it is not feasible to erect tall masts through enemy or contested territory. Additionally, airborne perturbations such as rain, fog, or dust can cause significant degradation in the data rates of the system (Magnuson, 2014). This is particularly troublesome for a military communications system, which must be highly reliable at all times and in all environments.

B. RELAY PLATFORM

As discussed previously, satellite offers a relatively expensive option to circumvent the shadowing phenomenon created by large vertical obstructions to electromagnetic propagation. A more inexpensive solution may be found in non-orbital platforms. More specifically, aerial platforms such as Unmanned Aerial Vehicles (UAVs) or High Altitude Balloons (HABs) may offer a platform capable of addressing the shadowing problem while extending electromagnetic propagation.

1. Unmanned Aerial Vehicle

Unmanned Aerial Vehicles (UAVs), also known as drones, is a relatively new technology. While specific UAV systems are stable, the market is budding with new developments in associated systems and subsystems used by the new technology. This feature makes research into the field particularly difficult due to the constantly changing foundation upon which the technology is built. Based on the research done for this study, it seems likely future models of UAVs will likely be capable of providing a relay platform for a long-range communication system that can solve the shadowing problem presented in this study. However, for reasons outlined in the remainder of this section, current models of UAVs do not appear to provide a simple economical solution to counter shadowing effects in long-range communications. For ease of understanding, this research divided the various systems currently available into three categories based on method of lift: rotary wing, fixed wing, and hybrid.

a. Rotary Wing

Rotary winged drones are most commonly seen in commercially available systems and involve several horizontally rotating wings, which create the lift required to fly (Vergouw, Nagel, Geert, & Custers, 2016). Rotary systems tend to be smaller due to power and weight constraints created by larger rotary systems (Vergouw et al., 2016). For similar reasons, most models are only capable of sustaining flight for approximately a half an hour (Vergouw et al., 2016). Rotary systems have several benefits, which lend themselves to use as a relay station. These systems are capable of vertical takeoff and landing (VTOL), hovering, and pre-programmed flight. A rotary winged drone provides the capability of easily deployment by a squad after arrival to the assigned AOR. The primary disqualifier for rotary winged drones is the flight time. Maintaining communications for only a half hour at a time is not sufficient for the tempo and duration of current MAGTF operations. It should also be noted some but not all rotary winged systems are unsuitable due to altitude and payload constraints (3D Robotics, 2015).

Fixed wing drones have had use within the military structure for some time. Fixed wing systems typically have longer uptimes than do their rotary cousins due to the larger fuel sources they can employ such as kerosene, fuel cells, and solar cells (Vergouw et al., 2016). The large UAVs commonly used by the military average 10 hours of flight time per sortie, have a range of 770 miles, and a ceiling of 25,000 feet (United States Air Force [USAF], 2015). Additionally, their payload can weigh up to 450 pounds; which, far exceeds the payload of a viable communication relay (USAF, 2015). Currently, the military typically utilizes this UAV for armed reconnaissance, airborne surveillance, and target acquisition (USAF, 2015). The MQ-1B Predator reached initial operational capability in March 2005 and as of September 2015, there are 150 units fielded (USAF, 2015). Part of the reason for so few being fielded is the cost; one MQ-1B Predator costs the government $20 million to produce (USAF, 2015). For these larger fixed wing UAVs, given the production, operating, and opportunity cost associated with use, it is not feasible to have these systems serve as a communications relay platform. Additionally, these systems require an additional command and control element due to the remote piloting required for navigation. This adds to the frequency congestion problem the military and civilian sectors faces as well as adds coordination requirements for the military to ensure proper cohesion.

b. Fixed Wing

Several smaller variations of fixed wing drones exist and could serve relay functionality in a communication system. The Raven is a smaller fixed wing system developed in 2002 and in relatively large use by the U.S. Army (Vergouw et al., 2016). The system weighs 2 kilograms, has a flight time of 60–90 minutes, is launched by a human throw, lands by gliding toward a landing site, and cushions the impact of landing by breaking apart at designated locations within the system (Vergouw et al., 2016). The primary disqualifier for the Raven is the payload; given the system only weighs 2 kilograms it does not support a payload necessary for relaying communications at the required ranges. The ScanEagle is also a small variation of the fixed wing drone. Primarily used for surveillance, it boasts a 20-hour flight time and requires little space for takeoff or landing (Vergouw et al., 2016). Unlike the Raven, the ScanEagle weighs 18 kilograms (Vergouw et al., 2016). The primary disqualifier for the ScanEagle system is the advanced pneumatic pressure system required to launch the system and the skyhook system required to retrieve it (Vergouw et al., 2016). This presents challenges for a squad of soldiers deployed in an austere environment expected to launch and retrieve the system.

c. Hybrid

Hybrid drones consist of systems that either have both rotary and fixed wing components or have neither rotary nor fixed wing components. This category represents the cutting edge for drones and as such are the most unstable and untested systems. Ornithopters are drones that mimic the flight pattern of birds or insects (Vergouw et al., 2016). These systems are created on the same scale as the animal being mimicked and as such are too small for serious consideration within the contexts of this study. Latitude Engineering’s HG-60 drone is a hybrid drone consisting of rotary and fixed wing components. The system currently holds the record for the longest flight by a VTOL aircraft at just under 22.5 hours (Atherton, 2015). This system could provide a suitable relay platform for the type of communications system designed for this study but the system is currently still in the testing phase.

Figure 1. Latitude Engineering’s HG-60 Drone. Source: Atherton (2015).

2. High Altitude Balloon

Balloons have a long and storied history with the military. American forces first used balloons during the Civil War for reconnaissance (Reitinger, 1993). For this discussion, a High Altitude Balloon (HAB) refers to a super pressure balloon capable of ascending thousands of feet and maintaining altitude for a significant duration (Reitinger, 1993). HABs achieve buoyancy through the use of a strong sealed envelope containing lighter-than-air gas (Reitinger, 1993). The Office of Naval Research was performing tests on this technology in the early 1950s (Madison, 1961). HABs were used to lift and drop dummies from altitudes ranging from 30,000 and 98,000 feet in order to test parachutes (Madison, 1961). HAB technology allows for days to months of aerial flotation; however, it is difficult to keep the balloon stationary for this amount of time due to winds (Hawkins, 1989). The longest duration this research found for the flight of a HAB was 744 days (Epiey, 1990). It should be noted, the flight and payload characteristics of a HAB vary widely and are largely dependent upon the envelope construction, the gas used, and the payload. The relevance to this study is the possibility of utilizing this technology as a platform for an intermediate device capable of transmitting and receiving communication signals, that is a communications relay capability.

This chapter of the study reviewed the available technologies with the potential to function in a system designed to answer this study's research questions. As previously discussed, several technologies show great promise and several of the technologies discussed would not fulfill the needs of the study or the USMC. The following chapter discusses the methodology used to identify the system components as well as the methodology used to evaluate the system.

III. METHODOLOGY

This chapter discusses the specific needs of the USMC, the methodology used to choose the system components, a description of the system created, and the procedures used to evaluate the capabilities. The USMC currently has many systems with far reaching ranges but none that meet the ranges required by the new methods of operation created by the MV-22 Osprey save the use of satellite communications. The majority of the systems capable of extended ranges are radio systems. Due to the new modality of operations, the USMC has new requirements for its communications systems. The USMC seeks a system that is capable of passing enough digital data to communicate simple chat messages to deployed units up to 700 miles away. The system must also be mobile enough to support a group of infantrymen conducting mobile operations in austere environments where environmental features produce the shadowing effect. This entails a system that adds minimal weight to the deployed gear as well as precluding the availability of a vehicle as a platform and power source.

A. SYSTEM DESIGN METHODOLOGY

In order to provide a solution the USMC could easily and inexpensively replicate, this study focused on adapting existing systems to generate the new capability. Ultimately, it was decided to focus on adapting the method of use of a radio system in the current inventory to meet the objectives. A radio system provides several advantages should a technology demonstrator prove successful. The primary benefit of radio signals is the innate ability of shortwave frequencies to reflect or refract off the atmosphere allowing for beyond line of sight communications. Utilizing shortwave radio frequencies helps minimize risks associated with establishing such long-range communications because short wave propagation inherently reaches these lengths. Utilizing a radio medium also confers other benefits. Radio is a very stable technology and with widespread use within the DOD. Several of the radios utilized by the DOD are designed to pass digital data through the system. The DOD has established expertise, supply chains, and acquisition experience with radio systems. A portion of the rationale involved with selecting radio waves as a medium involves the ease of transition the DOD will likely experience when adopting the system compared to a new immature technology. Where possible, this study sought to use a radio system currently in use by the DOD affording the USMC the benefit of minimizing the effort to transition, utilize existing purchase options, maintenance structures, and previously fulfilled security requirements.

While radio provides a medium offering the benefits noted above, an investigation is still necessary into the remaining system requirements and if a radio system could be adapted to meet those requirements. The mobility aspects of the requirements disqualified some radio systems. Particularly, those radio systems requiring large power sources and/or large hardware such as antenna towers to achieve radio propagation. Fortunately, several radio systems in use by the DOD are handheld and capable of transmitting shortwave frequencies. Initially, it was unclear if these devices could maintain the long ranges given the smaller form factor necessitating weaker power supplies and smaller antennae.

Radio by itself does not solve the problem of clearing large vertical obstructions near the area of transmission. To meet this requirement, this study sought to utilize a radio relay station that could be elevated. As noted in Chapter II, this study ceased further investigation of a satellite solution due to the costs associated with the procurement of a satellite or the purchase of time or data on another entity's satellite(s). This study also ceased further investigation of a UAV platform in part due to cost but primarily due to the additional command and control requirements a UAV introduces. A UAV typically requires a pilot and additional lines of communication allowing the pilot to fly the platform as well as provide the pilot with the necessary information a normal aerial vehicle provides via onboard instrumentation. Automated piloting of a UAV was deemed too immature a technology to consider within the scope of this particular application. Ultimately, this study prioritized the investigation of high altitude balloons (HABs) as the platform for a radio relay.

HABs require minimal C2 support usually only outfitted with a radio link for vertical navigation. The drawback of minimal C2 for the HAB is the ability to control its location; more specifically, horizontal navigation is to a large extent dependent upon the prevailing winds and general environment. While a UAV has a larger C2 overhead, it is able to maintain a precise location much easier than a HAB. The HABs investigated by this study were only capable of indirect control of their vertical position through the clever use of the lift gas and the controlled weight of a small amount of ballast. The only real means of horizontal control of a HAB is through the vertical placement of the platform between constantly changing wind streams. Despite these drawbacks, a HAB can typically stay within range for several hours; and, compared to other aerial platform technologies, is cheap enough to deploy repeatedly should a HAB drift out of the desired range.

For the text communications requirement, this study sought to identify a potential solution within the DOD's current capabilities. The text capabilities would have to be robust enough to not limit communications between end-nodes yet simple enough to have minimal overhead within the network. Minimal overhead helps maximize throughput on the network. Maximizing output not only serves to provide efficient communications; it helps provide communications that are more reliable. Reliable communication equates to minimal loss of communications during periods of minor environmental or electronic interference.

B. SYSTEM DESIGN

The system designed for this study utilizes three radios. Two radio operators use a commercial off the shelf tactical handheld radio while a third radio relays data messages between the first two. The radio serving the relay function is mounted to the tail of the HAB. Both end-point radios are connected to a laptop via a model 850 ViaSat Data Controller (VDC). Each laptop hosts a program called ViaSat eMail (Vmail), which enables chat functionality.

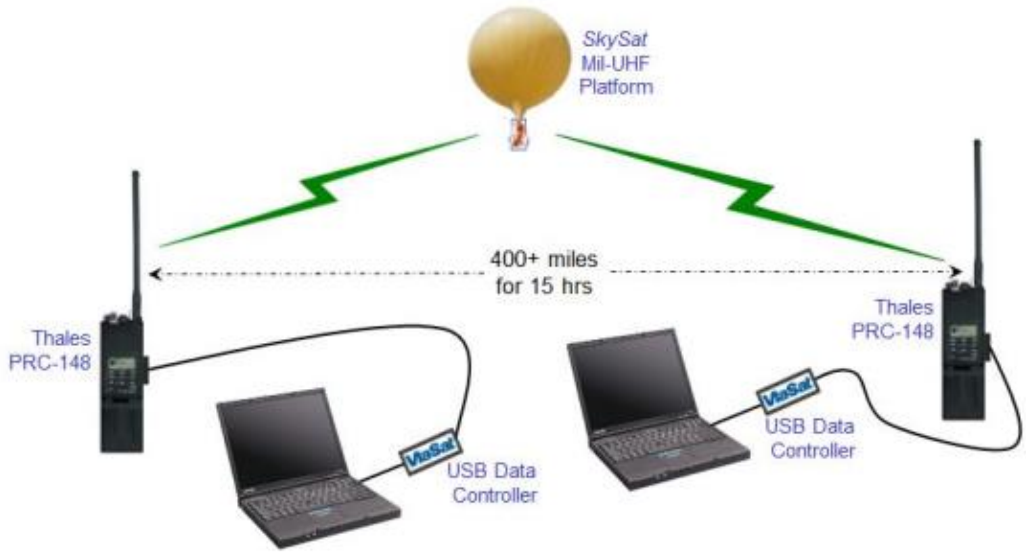


Figure 2. Example of a Similar System to the One Created in This Study.

Modern U.S. conflicts have demonstrated the continued trend towards joint and coalition modalities of operations. This study also sought, if possible, to demonstrate wireless data connectivity between two different commercial radios capable of delivering data over radio. The NPS had in its inventory Harris 7800M-HH radios and Thales Multiband Inter/Intra-Team Radio (MBITR) radios. Both radios have the ability to transmit data over an analog signal "out of the box" and have been designed to do so with the same model radios requiring minimal configuration. These radios were tested in an attempt to provide a technology demonstrator for a vertically-suspended relay system. The requirement to establish a data connection was met utilizing a RF-7800M-HH Harris radio and a MBIRTR/PRC-6809 Thales radio. Detailed setting configurations for the RF-7800M-HH and the MBITR/PRC-6809 radios can be found in Appendices A and B, respectively.

The VDC-850, laptop, and Vmail application serve to send and receive the data packets sent through the aforementioned radios. The VDC-850 serves to encapsulate and de-encapsulate the data in a similar fashion to a network Ethernet adapter. It also performs timing and modulation functions necessary to transmit the data over a radio medium. The laptop serves as the display and input device as well as the platform for the

Vmail application to function upon. The Vmail application serves to translate the ACSII information to and from digital data for the VDC-850. Detailed configuration for the Vmail application and VDC-850 can be found in Appendix C.

The relay platform used during this evaluation was a SkySat Repeater Platform manufactured by Space Data ® Incorporated. This system provides a high altitude radio repeater via a rapid launch balloon. The system utilizes a military UHF repeater operating within a frequency range of 225–375 MHz. For the purposes of this study, this system served as the aerial relay subsystem for communication between the two operator radios.

Figure 3. SkySat Subsystem Prior to Launch.

Figure 4. SkySat Subsystem Shortly After Launch.

C. EVALUATION PROCEDURES

The following section covers the procedures followed to gather the data discussed in Chapter IV. The procedures were executed with assistance from a Space Data Corporation (SDC) engineer. The system described was constructed in a lab environment. Prior to evaluation, SDC performed calculations for expected drift patterns of the balloon based on weather data. The drift calculations were performed utilizing proprietary software created by SDC. After setting up the system, the first procedure was to establish a data connection in a lab environment. A radio relay, established by SDC employees, was used to establish a data link between the operator radios. The radio relay mimicked the relay deployed on a SDC SkySat balloon configuration. After a satisfactory bench test, the team began the procedures for the SkySat balloon launch.

The 2000 gram SkySat balloon was filled to a diameter of approximately 15 feet using helium. After filling the balloon to the appropriate volume, the balloon was held down by personnel while a short equipment check was performed on the balloon-hosted system. The equipment check consisted of a vent, ballast, and communications test of the balloon’s control mechanisms. Prior to launch, another data link check was performed to ensure no system malfunctions had occurred. Great care was taken to avoid skin contact with the balloon’s surface. As oil generated by human skin has negative impacts on the material of the balloon and its ability to keep a tight seal at high altitudes. The smallest pin-hole can have drastic impacts on the ability of the balloon to reach cruising altitudes and maintain the intended flight duration. The balloon was walked approximately 50 feet from obstructions and released.

Another systems check was conducted after the balloon reached a cruising altitude of 60,000 feet. This check was conducted prior to deploying the radio operators. After a successful final function check, the radio operators were deployed to simulate mobility as well as prove the system was capable of communicating over a base range. During the flight, data was captured on the balloons telemetry and control system status.

The data connection between the hosted laptop computers was demonstrated through the successful receipt and transmission of chat messages between the laptops utilizing the radio links. The "deployed" radio operator simulated a mobile operations tempo through driving to various areas in Phoenix, AZ. Throughout the various movements of the radio operator, the balloon drifted as expected and in accordance with local wind patterns. After the flight was concluded, Space Data retrieved and refurbished the SkySat balloon platform for future use.

Figure 5. Sample of Data Captured by SkySat Telemetry.

Figure 6. SkySat Flight Tracking During Evaluation Procedures.

This chapter provided a review of the methodology used to conduct this study. More specifically, it provided a detailed description of the system and the design process used to determine it. It also identified the procedures used to evaluate the system's capabilities based on the USMC's requirements. The following chapter will provide a review of the data obtained through the evaluation as well as data analysis.

IV. RESULTS

This chapter discusses the results of the designed system's evaluation as described in Chapter III as well as an analysis based on the data and observations. It has been divided into the following sections: Evaluation Preparation, Pre-Evaluation, Evaluation, and Analysis. The system design and evaluation was conducted with a significant contribution from Space Data Corporation (SDC) engineers in accordance with a contract let to assist with this effort. SDC conducted similar experiments in 2008 successfully transferring text and image data over a radio network ("USSOCOM-NPS field experimentation cooperative program: Tactical network topologies," n.d.). During these experiments, the system's range was not explored in-depth and the end-point radios were the same model. However, SDC provided indispensable input and feedback based on their prior experience.

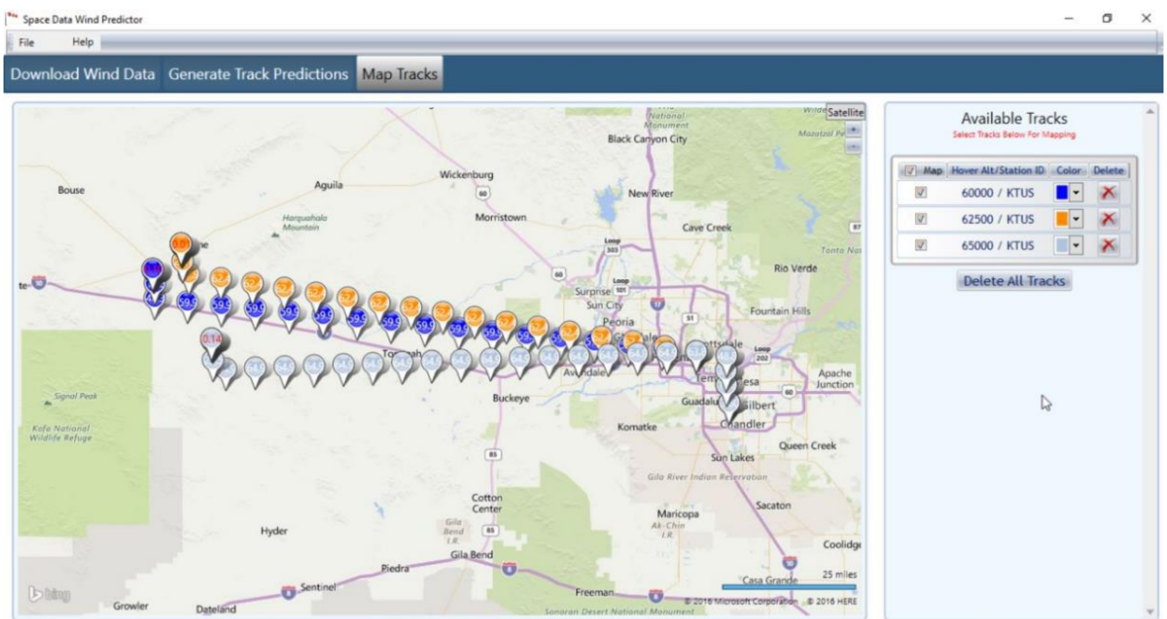
A. EVALUATION PREPARATION

Beyond the assistance rendered in system design and evaluation, SDC is the developer and manufacturer of the SkySat HAB system. One day prior to testing, on 20 July 2016, SDC engineers calculated the expected atmospheric environment for the evaluation day. They performed these calculations utilizing their proprietary software, Predictor, in conjunction with National Weather Service data. The calculations were utilized to identify the expected drift patterns of the SkySat HAB as well as weather conditions that might have precluded a proper system evaluation.

The system setup portion of the study required considerable effort consisting primarily of trial and error in order to identify the correct configuration as no prior known effort attempted to interface the two disparate radios in this manner. More specifically, the timing settings were very consequential in establishing a relatively low latency connection between end devices. A key portion of the lab configuration was dependent upon information gleaned from ViaSat documentation. The relevance of the difficulty involved in proper configuration is explored further in the Analysis section. Within the lab environment, a radio relay was established to mimic the radio relay of the SkySat HAB for the purpose of pre-evaluation system checks.

B. PRE-EVALUATION

The evaluation was conducted on 21 July 2016. The morning was spent fine tuning various radio and software settings to optimize the system. The end point radios were first put into a simplex configuration to establish connectivity directly between each radio without the radio relay. After several successful communications between radios in this mode, the system was altered to pass communication signals through the repeater previously installed in a test-bay to mimic the radio relay installed on the SkySat HAB. After establishing confidence in the system configurations, the focus shifted toward a successful launch of the SkySat HAB.



The flight paths presented are the predicted flight paths of the SkySAT HAB based on weather data.

Figure 7. Image of Space Data’s Predictor Software.

SDC provided a staging area within their facility for the SkySat HAB. The staging area was prepared with the deflated SkySat HAB placed upon a tarp. Within this staging area, the HAB was filled with a lighter than air gas to a diameter of approximately 15 feet. All members handling the HAB wore gloves to reduce the chance of skin-to-HAB contact and consequently maintain its structural integrity, as oils from the skin can degrade the material of the balloon. Visual and audial examinations were conducted by two members of the evaluation team over the surface of the HAB. The examination was conducted to identify any leaks of gas through the surface of the HAB. No visual or audible leaks were observed during this examination.

After the examination for leaks, team members moved the HAB to the launch area outside the facility, ensuring contact was avoided between the HAB and any surface along the route. After reaching the launch area, the HAB was anchored by human weight while a HAB control system evaluation was conducted. The HAB control system evaluation consisted of telemetry, sensors, ballast release, and venting systems checks. All control systems were observed to be functioning adequately. The SkySat's telemetry and flight controls were integrated into a single software application held on a separate laptop, henceforth referred to as the ground station. As a part of the ground station functionality, the SkySat's telemetry and system health data were recorded at intervals of approximately 2 seconds throughout the system evaluation. The HAB was released by hand at 11:00 PM and rose to a cruising altitude of approximately 68,000 feet over the span of 36 minutes, an average ascent of 30 feet per second.

Figure 8. Image of Flight Control Software Utilized for SkySat Operations.

C. EVALUATION

At this point of the evaluation, the system consisted of two laptops, two handheld radios, two VDC-850 MODEMs, the SkySat HAB, and the relay radio attached to the HAB undercarriage. The handheld radios utilized were the Harris 7800M-HH (Falcon-III) and Thales PRC6809 (MBITR). As the SkySat HAB rose to cruising altitude, several evaluations were conducted from the parking lot of the SDC facility. The first task was a post-launch system evaluation under the new configuration in which a message was sent from one laptop to the other through the system components. The post-launch system evaluation was successful. While the SkySat HAB continued to rise, several files of various sizes were transferred through the system. The largest file transferred was over 85 kilobytes. Particularly relevant for this study, several images were transferred through the system. The relevance of transferring images through the system will be further discussed in this chapter’s analysis section. The typical time observed for successful text communications, i.e., chat, was 3 seconds. The typical time observed for successful image transfers was 2.5 minutes. The following sections provide more details regarding the flight results.

Figure 9. Google Earth Image of SkySat Ascent via Telemetry Data.

1. Portion A

The first ground team, Vehicle 1, left the SDC facility at 12:37 PM carrying the Harris 7800M-HH/VDC/laptop portion of the system. The second ground team, Vehicle 2, possessed the Thales 6809 based subsystem and remained in the parking lot of the facility. Directly after the departure of Vehicle 1 from the SDC facility, Vehicle 2 lost the ability to send or receive communications for 20 minutes. Vehicle 2 was only able to restore its connection after performing a restart of its associated laptop. After restarting the laptop in Vehicle 2, multiple messages were sent and received by both vehicles. Note that direct communications between the vehicles over the configured system was not possible as the radios were configured to communicate with the relay aboard the HAB and not with each other. That is, they did not have a channel configured for one radio to receive directly from the other.

The distance between the two vehicles grew through this portion of the evaluation as Vehicle 1 drove away from Vehicle 2 still parked in the Space Data parking lot. The maximum distance between vehicles during this portion of the evaluation was 7.5 miles. During this portion of the evaluation, the distance between the SkySat HAB and Vehicle

1 was approximately 24 miles while the distance between the SkySat HAB and Vehicle 2 was approximately 18.88 miles. Throughout the remainder of the evaluation, the distance between the SkySat HAB and the vehicles continued to grow as wind patterns took the HAB farther away.

Figure 10. Google Earth Image of SkySat Flight Path for Portion A via Telemetry Data.

2. Portion B

Communications between the two vehicles were restored at 1:06 PM. From 1:06 PM to 1:37 PM, 27 successful messages were transmitted through the system. Similar to the lab environment, successful messages took 2–3 seconds to successfully make it from endpoint to endpoint. No images were transferred during this period. The distance between the two vehicles and the HAB began at approximately 21 miles and grew to approximately 50 miles throughout this portion of the evaluation.

Several errors were observed during this phase while attempting to send messages through the system. All errors observed throughout the evaluation resulted in failed transmissions. Throughout the entire evaluation period, Vehicle 2, carrying the Thales portion of the system, experienced intermittent unresponsiveness of the VDC. While the VDC of Vehicle 2 was unresponsive, Vehicle 2 was unable to send or receive messages through the system. This error occurred eight times throughout the evaluation and during this portion of the evaluation it accounted for three errors. Of the eight errors throughout the evaluation, seven errors originated from Vehicle 2 and one VDC connection error originated from Vehicle 1, carrying the Harris radio. The VDC connection error originating from Vehicle 1 occurred prior to the evaluation period during system checks and was associated with transferring image files. The source of the intermittent unresponsiveness is unidentified but believed to be related to interoperability issues between the laptop, VDC, and the Thales radio.

Additional errors were observed relating to a channel acquisition timeout. The channel acquisition errors were observed five times during this portion of the testing. These errors appear to be evenly distributed throughout this portion of the evaluation but are overrepresented in this portion compared to the entire evaluation. It should be noted that when a VDC is unresponsive, attempts to directly communicate with the affected endpoint are identified as channel acquisition errors. Therefore, it is possible any channel acquisition error is actually an unresponsive VDC discovered from the opposite end of the system. The author believes it to be an unlikely occurrence due to the frequency with which both endpoints were communicating but recognizes this possibility cannot be disproven with the available data. The source for the channel acquisition error is also unidentified but a likely cause is an interrupted signal caused by strong winds creating a swinging antenna on the HAB.

Figure 11. Google Earth Image of SkySat Flight Path for Portion B via Telemetry Data.

3. Portion C

This portion of the evaluation represents the messages transmitted between 1:37 and 2:24 PM. During this time, both vehicles were mobile while communicating. The author observed 36 successful transmissions through the system. The author observed five errors; of these errors, three were concerned with VDC recognition in Vehicle 2, one involved a channel acquisition timeout, and one involved no acknowledgements received by Vehicle 2. The latter error's source is unknown but likely caused by a momentary loss of connectivity in the midst of a transmission. The distance between the HAB and the vehicles started at approximately 50 miles and finished at approximately 60 miles throughout Portion C of the evaluation.

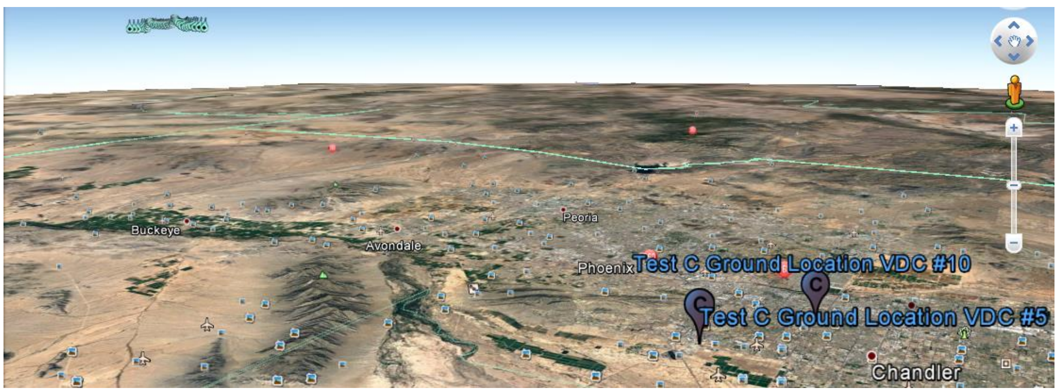


Figure 12. Google Earth Image of SkySat Flight Path for Portion C via Telemetry Data.

4. Portion D

Portion D represents the messages transmitted between 2:24 and 2:51 PM. During this portion of the evaluation, both vehicles were also mobile. The primary difference between Portion C and Portion D is the reliability of the system and the distance between the Vehicles and the SkySat HAB. The distance between the HAB and the vehicles started at approximately 60 and finished at approximately 85 miles throughout Portion D of the evaluation, representing a system end-to-end distance of 170 miles. During this portion, 17 messages were successfully transmitted through the system and eight errors were observed resulting in unsuccessful transmissions. Of the errors observed, one error was caused by no VDC recognition and the remaining errors were caused by channel acquisition faults. Of the channel acquisition errors, five occurred in Vehicle 2 and two occurred in Vehicle 1. The system evaluation concluded when an unexpected failure occurred in the SkySat HAB and it descended rapidly. Space Data later retrieved the fallen SkySat HAB used during the evaluation, affected repairs, and returned it to their inventory.

Figure 13. Google Earth Image of SkySat Flight Path for Portion D via Telemetry Data.

D. ANALYSIS

The system created through the execution of this study successfully transmitted text data to and from mobile and stationary end points. The system was somewhat reliable; it successfully sent and received most messages. Of the 118 message attempts on the day of the evaluation, 83 were successful. If the errors associated with the laptop reboot are discarded, the ratio of successful transmissions to unsuccessful transmissions is approximately 4:1. When transmissions were successfully passed through the system, the transmission speed was adequate usually taking only a few seconds. In addition to transmitting text data, larger data files in the form of images were transferred through the system. The files transferred were large compared to text messages but the transmission appeared to be as reliable as the text messages. It should be noted the quantity of file transmissions executed was much smaller than the quantity of text message transmissions but the primary function of this study was not an examination of the system’s ability to transfer large files. It should also be noted, the transmission of files took far longer than the transmission of text. Much of the difference between text and file transmission times can be attributed to the system's low data rate, the difference in file sizes, and the manner in which the system self regulates data flow when overwhelmed. Finally, no images were transmitted through the system after the evaluation began.

Another important system feature successfully demonstrated was the range of the HAB relay functionality. This study successfully demonstrated the ability to pass data through the platform via a radio medium. More specifically, the system was able to successfully transmit text messages over ranges exceeding 80 miles between nodes. Although not specifically tested in this study, the implication of an 80 mile transmission range between nodes is a 160 mile range transmission if each end point radio is located on opposite sides of the HAB platform. The range observed during the evaluation portion of the study is not sufficient for the USMC requirements. However, the maximum transmission range achieved during the evaluation was constrained by an unexpected failure in the HAB not a limitation of the system to successfully transmit at larger ranges.

1. Errors

One area of the study deserving discussion centers around the errors observed throughout the evaluation. Over a third of the errors observed occurred during the system malfunction requiring the laptop reboot. Although these errors are significant and meaningful, the author did not believe they represented the system's normal operations nor gave accurate feedback to the capabilities of the system. For this reason, when analyzing the transmission reliability of the system, these errors were not taken into account. However, the system is clearly capable of this type of system failure and these results do speak to the system's viability within a military environment. No definitive explanation was found during the course of the study as to why a laptop reboot was required to restore operations. In hindsight, the set of errors associated with this system failure enlightened the potential causes of errors throughout the evaluation.

The first and only error of its type during this period was from the affected half of the system and related to a lack of acknowledgement from the functioning portion of the system. The negatively affected portion of the system was Vehicle 2. Vehicle 2 contained the Thales 6809 radio and associated portion of the system while Vehicle 1 contained the Harris 7800M-HH radio and associated portion of the system. The remaining errors were attributed to a timeout associated with acquiring the transmission channel. The likely explanation is the laptop's Vmail software in Vehicle 2 of the system began improperly communicating with the attached VDC and/or radio and doing so in a manner that appeared correct to the software. In this scenario, observations of the software on the affected laptop lead the observer to believe all communications being transmitted transited through the attached radio but were not received by the opposite end node, in Vehicle 1. However, if the message transited to the VDC but could not transit further, it may appear to the software the transmission was successful despite not properly transmitting further. During this period, neither radio could make direct contact with the other. However, the radio in Vehicle 2 attempted two broadcasts and both were subsequently reported successful by the Vehicle 2 software. The functioning portion of the system, Vehicle 1, did not receive either broadcast. Broadcasted transmissions do not require a specific channel to connect to prior to transmission. Consequently, if the messages had been transmitted through the radio in Vehicle 2, Vehicle 1 would have likely received the message. These observations combined with the returned functionality of the Vehicle 2 portion after rebooting the laptop points toward an error between the laptop and radio in Vehicle 2 as the cause of the system downtime.

More importantly, several transmission errors throughout the remainder of the evaluation were associated with Vehicle 2 not recognizing the associated VDC despite being physically connected. There were no errors of this type observed by Vehicle 1 during the evaluation. Additionally, channel acquisition errors were observed by both vehicles throughout the evaluation. It is possible, similar to the system malfunction, Vehicle 2 continued malfunctioning but to a lesser degree throughout the evaluation period. If this were true, both sides would report channel acquisition errors throughout the evaluation. This would lead an observer to believe the system inherently fails to transmit some messages when in fact all messages would have been properly transmitted if not for the intermittent connectivity in Vehicle 2.

It is important to again point out both vehicles had different radios transmitting and receiving the data. Additionally, the radios functioned slightly differently. It is possible the laptop, Vmail application, and VDC were more tolerant of maintaining the connection to one radio compared to the other. Given the lack of "No VDC" errors in Vehicle 1, this conclusion seems highly probable. No other combinations of radios were evaluated within the system during this study. Therefore, this study cannot definitively prove or disprove the cause of the transmission errors observed being attributable to a difference in radios at either side of the system.

2. Usability

The U.S. military has a history of identifying and exploring capability growth in its systems. Prior to conducting the evaluation, the system successfully transmitted images from one end-point to another. Although the system was not specifically designed to perform this function, it does establish an area of capability growth should the USMC and the DOD at large decide to explore and implement it. More research is necessary to identify the constraints of this capability; however, successfully implementing this feature could significantly enhance the system's concept of operations. For example, a functioning image transfer capability within the system could allow for enhanced intelligence gathering in the form of images for facial recognition or finger print collection while deployed. This functionality was demonstrated during the aforementioned SDC technology demonstrator utilizing homogenous radios ("USSOCOM-NPS field experimentation cooperative program: Tactical network topologies," n.d.).

As previously stated, significant time was spent configuring the system settings to allow for relatively reliable and low latency communications. As part of the evaluation, this study intended to identify and explore any correlation between range and reliability. The premature failure of the SkySat HAB precluded obtaining the necessary data to establish any correlation between these two system characteristics. However, as with all radio systems, the system designed within this study has a range where further communications cannot be reliably transmitted. It is a reasonable assumption to make, based on how the system operates, as transmission ranges increase the optimal configuration settings of the system will change. Other factors may also affect the optimal settings such as weather conditions and the ambient electromagnetic interference adding further variability to the optimal system settings. Without a means to automate the identification and implementation of these settings, the user must manually and possibly continually optimize the system. Given the expertise and operational tempo of deployed forces, continually optimizing system settings may not be feasible for the deployed forces intended to utilize this system.

This chapter of the study covered the data, observations, and analysis made following the methodology dictated in the previous chapter. The evaluation conducted on the system successfully demonstrates the functionality of the system as designed. However, additional experimentation must be performed to determine the cause of the drop-outs between the end user devices. This chapter also provided an analysis of the system’s capabilities based on the evaluation performed. The following chapter discusses conclusions drawn by the author based on the data, observations, and analysis. The following chapter also discusses implications to other areas of interest involved with the intended system use by the USMC and areas for future work. Detailed data and results can be found in Appendix D.

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V. ANALYSIS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter provides conclusions based on a holistic view of the system designed and its intended use within the USMC. Finally, this chapter discusses future areas of work with respect to this study as well as associated areas of interest not directly tied to this study but important to the greater effort involved with providing the USMC a particular capability.

A. CONCLUSIONS

This portion of the chapter provides conclusions based on the study's results as it applies to the purpose. Although the designed system was successful, at present it does not meet the USMC needs. This study was the first step towards identifying a system that provides the necessary capabilities. With this in mind, it is important to identify what was learned about the system and translate that learning into valuable conclusions for the USMC.

1. Radio Systems

As stated in Chapter II, utilizing radio as the primary transmission medium confers various benefits. The technology has widespread use within the DOD, and as such, the USMC is poised to implement a radio solution more quickly than a newer technology, e.g., free space optics. Utilizing radios that have been previously procured saves money compared to the procurement costs of a new system and the disposition costs of legacy systems. The DOD can leverage existing supply and maintenance chains to more easily support the technology instead of conducting the logistical preparation and execution of new chains. Existing knowledge management and training can also be leveraged on a system utilizing existing technology and devices. Finally, a major benefit of utilizing existing radio technology involves the security process aspect. Security processes, as they relate to information technology, have increasingly become a priority for the military at large for its systems. As a result, the processes around approving the security protocols of a new system or new technology are very exhaustive and time intensive. Utilizing existing radio technology allows the USMC to leverage much if not all of the security reviews and protocols already in place for the existing radio systems.

If a radio medium is chosen for providing the previously stated capability to the USMC, it must be noted the system will inherit the various drawbacks associated with radio communications. Compared to other forms of data networks, radio systems typically experience much lower data rates. It should also be noted, high throughput was not a requirement of this study nor is it a requirement to meet the USMC needs. However, systems in the military often experience capability growth over the lifespan of the system. Systems are often adapted to increase capability or make existing capability more robust. Consequently, a radio data network will suffer from a constrained growth potential with respect to throughput. This is especially important given the increasing throughput requirements by the DOD at large.

Another drawback of radio systems that further exacerbates this issue is congestion in the radio frequency (RF) spectrum. The RF spectrum must be shared with other nations, agencies, and commercial enterprises. Consequently, the military will have bandwidth constraints for the foreseeable future with respect to the RF spectrum. Additionally, the military must prioritize this scarce resource amongst its various objectives and services. Capability growth is limited for a radio system designed to meet the current needs but expected to meet the future needs.

Despite adhering to the exhaustive security review processes in place, radio systems also have inherent security drawbacks. Many radio systems, including the system designed in this study, do not perform directional propagation. This feature makes communicating with an entity whose precise location you are unsure of much easier. For example, non-directional communication with a HAB is easier for troops unable to visually identify the platform; especially so, if it has drifted from its last visual location. The downside of non-directional propagation is the ability of an enemy combatant or non-ally to identify the occurrence of a transmission. This has clear implications for a force expected to remain hidden. A non-directional transceiver has additional security concerns. If the enemy can identify a foreign presence and identify the transmission frequency, the enemy has the potential to jam the signal by bombarding the frequency with overpowering noise. In doing so, the enemy can deny communications to an otherwise functioning system. Other data mediums, such as free space optics, make the process much more difficult for the enemy simply by the inherent properties of the transmission medium. Finally, for a non-directional transmission, the enemy can easily receive the transmission with little effort. Interception is typically countered via clever manipulation of the propagation signal and applying cryptologic methods to the message. It is much more difficult to intercept transmissions on other mediums such as directional microwave or free space optics.

2. HAB

The HAB utilized for this study also has inherent benefits and drawbacks compared to other potential relay platforms. Although not tested in the course of this study, the HAB has the potential to be launched from the field. This capability is necessary to combat the shadowing effect and provides a much more responsive capability to fielded soldiers. In contrast, a drone would require extensive pre-planning for the desired range or a small size and consequently limited operational duration. A satellite is unaffected by the shadowing affect and less coordination is required for use; however, the cost and subsequent prioritization to higher level needs often preclude it from being a reliable platform for field operations. The HAB is also relatively cheap to procure and maintain. Additionally, cost savings exist for successful retrieval of the HAB after operations; however, the reality of retrieving a HAB in enemy territory may preclude seizing this cost savings.

Despite the benefits of a HAB platform, there are consequential drawbacks to its use in a military system. Unlike a drone or satellite, it is not possible to maintain positive control over a HAB flight pattern. HAB flight control consists exclusively of vertical control not horizontal control. There is no means to counteract the effect of prevailing winds on the HAB platform other than to shift its altitude. This fact presents unique challenges to maintaining station, deploying in adverse weather, avoiding mid-air collisions, and the reliability of the transmission through the platform. Finally, a HAB platform has unique stealth constraints due to its size, low speed, and unique profile.

During the evaluation, the team lost visual contact with the HAB around 10 minutes after launch and the HAB took a little over an hour to ascend to cruising altitude. In a combat environment, if an enemy can identify the HAB during launch, the enemy will have an easier time identifying the presence and location of the USMC forces who launched the HAB. This can be mitigated through launching the HAB in a low visibility environment. However, HAB deployment is constrained by any overhead obstructions such as a canopy. Additionally, only deploying the HAB in a low light environment may prove unfeasible if the majority of that time is spent traveling to the destination as is the case in a MV-22 Osprey assisted deployment.

Finally, the flight control for the HAB is performed over a radio medium. Consequently, it suffers from many of the same drawbacks previously discussed for a radio medium. The HAB flight control is susceptible to jamming, identification, interception, and potentially hacking. The potential to hack the HAB flight controls is particularly important because the same security protocols used for the end point radios would likely not exist on the relay radio due to the probability of it falling into enemy hands should the HAB unexpectedly land due to failure or enemy actions. This fact makes the radio less secure and more prone to hacking.

3. System Design

Several observations, which warrant discussion, were made concerning the viability of the designed system for the USMC needs. After the evaluation period, the author attempted follow-on experimentation and faced significant challenges replicating the functioning system observed during the evaluation. The likely cause for the difficulty is a difference in laptop platforms used to replicate the system, as all other hardware remained the same. This gives cause for concern around the ability and ease in which the USMC may adopt the system. Additionally, the software utilized to send and receive messages is very dependent on a particular operating system to achieve functionality. Without further modification, this precludes other devices and operating systems from acting as surrogates for the Windows 7 operating system used during the evaluation. Given the recent proclivity within the DOD to provide smaller and more mobile devices to the field, this can present a problem if the system cannot function on a smaller device such as a tablet or phone.

B. RECOMMENDATIONS

This section of the chapter builds upon the analysis and conclusions previously presented to recommend paths forward toward meeting the USMC needs. Due to time and scope constraints there are several areas that require further evaluation concerning the system designed within this study. Several recommendations can be conducted within a similar study and system while others will require different methodologies and evaluations altogether.

1. HAB

Further research is needed into the reliability, durability, and capabilities of the HAB platform. Identification of the environmental extremes within which a HAB can be successfully launched and/or flown requires additional assessment. Given the austere operating environment typical of our deployed forces, additional analysis is needed to identify the minimum level of preparation and precaution required to successfully launch and fly a HAB. During this study's evaluation, the environment was purposely sterile, gloves were worn, and considerable preparation time was taken prior to launch. This may not be the case when launching in a mission environment and identifying the minimum amount of time and careful handling of the platform prior to launch would shed further light on the feasibility of deploying a HAB in the midst of a tactical mission.

Furthermore, additional assessment is needed in addressing the feasibility of an automatic or more remote control station for the HAB. It may be possible to reduce the cognitive load on deployed forces by shifting flight control to a higher unit or utilizing preplanned flight through automation. Finally, additional research is warranted to identify alternate forms of launch or recovery for the HAB. It may be possible to deploy and/or recover the HAB from an air platform. This not only reduces the responsibility and cognitive load of the deployed forces, it also relieves several HAB drawbacks concerning security. It may also be possible to pre-release a HAB accounting for drift so the HAB is on station when the unit arrives to its area of responsibility. Furthermore, it may be possible to deploy a constellation of HAB platforms thereby achieving minimal downtime and adding to the potential of extreme ranges of communication via relay nodes communicating in series where the HABs form a mesh network.

2. System

Further research is also needed to identify the maximum throughput and maximum range of the designed system. This information will speak most directly to the potential of the system to meet the USMC needs. Additionally, research into utilizing mediums other than radio on the system would prove beneficial. As previously discussed, other mediums provide higher throughputs and more security despite having less range. It may also be possible to communicate across mediums such that a deployed unit transmits to the relay device via a cellular medium and the relay device transmits to the controlling unit via a directional radio.

Further research is also warranted in understanding and reducing system errors. Research into the level of degradation, which occurs as the HAB rises to higher altitudes, would prove informative. Additionally, conducting the evaluation in a more frequency isolated environment may shed light on the effects of RF noise on the system's ability to transmit messages successfully. More research is needed to identify the degree of correlation between the range, reliability, and system configuration to reduce errors when transmitting. Lastly, the dependence on a specific operating system by the software utilized within the designed system could have adverse effects on long term viability. Research is needed to identify an alteration or an alternative to the software utilized in the study or the compatibility with future operating systems.

APPENDIX A. HARRIS RF-7800M-HH CONFIGURATION

The following is a list of configuration settings used on the Harris RF-7800M-HH radio to transmit successfully within the system described in this study.

- Audio Config
    - Radio Side PTT: Enabled
- External Keyline: Enabled
- Port Configuration
    - Port 1: ASCII
    - BAUD Rate: 115,200
    - Character Length: 8
    - Parity: None
    - Stop Bits: 1
- System Presets
    - Preset Waveform: VULOS
- General Config
    - Preset Type: LOS
- Frequency
    - Receive Frequency: As desired
    - Receive Only: No
    - Transmit Frequency: As desired
- COMSEC: None
- Traffic
    - Traffic Mode: Data

  - Data Mode: Synchronous
  - Modulation Type: FM
  - FM Deviation: 6.5 KHz
- Transmit Power: As desired
- Squelch
  - Squelch Type: Noise or Tone (if tone, must be matched throughout network)
  - FM Transmit Tone: Enabled
- Exit

APPENDIX B. THALES MBITR/PRC-6809 CONFIGURATION

The following is a list of configuration settings used on the Thales MBITR/PRC-6809 radio to transmit successfully within the system described in this study.

- Program
- Radio Config
- CH= <select desired channel number>
- Mode: Digital
- Transmit Power: Select desired
- Receive frequency: Select desired
- Transmit frequency: Select desired
- Subaudible (or "PL") tone **If tones are selected, the same tone must be used on all radios.
    - Receive R= <select desired>
    - Transmit T= <select desired>
- Mode: FM
- Data Rate: 16K
- RPTR: None
- Phase: .256s
- Sqlch: 6 or 8 dB (Select higher if noisy)
- Hit ESC button to leave the menu and save the previously entered settings.
- Global
- TX Timeout: INF
- BL Timeout: INF

- Side/Mic Lvl: Side Enable (Necessary for VDC-850 cable interface functionality.)

APPENDIX C. VIASAT EMAIL AND VDC CONFIGURATION SETTINGS FOR HARRIS RF-7800M-HH CONNECTION

Below are the settings for the ViaSat eMail and VDC-850, which connect to the Harris RF-7800M-HH.

Setup for the RF-7800M-HH (Non-CCI PRC-152) Radio		
ViaSat eMail - Setup / VDC Configuration		
	VDC Configuration General TAB	
	Field / Category:	**Setting / Value Used:**
Data Controller		
	VDC Type:	**VDC-850(USB Data Controller)**
Specific Settings:		
	Use VDC With Serial Number:	**Enabled**
	Channel Device:	**Contains a dropdown list with pre-configured settings for common radio's the VDC-850 might interface with. We found the all the preconfigured settings needed adjustments before they would pass data correctly.**
VDC Built-In Test:		
	Run BIT:	**Button function which runs the Built-In-Test of the connected VDC hardware.**

Setup for the RF-7800M-HH (Non-CCI PRC-152) Radio

ViaSat eMail - Setup / VDC Configuration

VDC Configuration MIL 188–184 TAB

	Field / Category:	**Setting / Value Used:**
Compliance:		**STRICT 184 COMPLAINCE UNAVAILABLE**
Compliance (Carrier Sense Multiple Access):		
	CSMA Enabled:	**Enabled**
	Probe Retries:	**4**
ARQ (Automatic Repeat Acks):		
	ARQ Enabled (Receiver Acks):	**Enabled**
	Burst Retries:	**8**
Burst Configuration:		
	Legacy Protocol MAX PACKETS:	**170**
	Enhanced Protocol MAX PACKETS:	**1024**
Forward Error Correction:		
	FEC Code Rate:	**1**
	Adaptive:	**Enabled**
Compression:		
	VDC Data Compression Enabled:	**Enabled**

Setup for the RF-7800M-HH (Non-CCI PRC-152) Radio

ViaSat eMail - Setup / VDC Configuration

VDC Configuration Delays TAB

	Field / Category:	Setting / Value Used:
Channel Access Delays:		
	Channel Access Speed:	Normal
Acknowledgement Delays:		
	Additional ACK Delays:	4
	Turn Around Delay:	2
Data Padding:		
	Transmit Start Delay:	2
	Transmit End Delay:	1
AN/PSC-5 Parameters:		
	CTS Tx Clock Timeout:	2
	RTS Off to On Delay:	0.5

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APPENDIX D. VIASAT EMAIL AND VDC CONFIGURATION SETTINGS FOR THALES MBITR/PRC-6809 CONNECTION

Below are the settings for the ViaSat eMail and VDC-850 which connects to the Thales MBITR/PRC-6809.

Setup for the PRC-6809 (Non-CCI PRC-148) Radio

ViaSat eMail - Setup / VDC Configuration

VDC Configuration General TAB

	Field / Category:	Setting / Value Used:
Data Controller		
	VDC Type:	VDC-850(USB Data Controller)
Specific Settings:		
	Use VDC With Serial Number:	Enabled
	Channel Device:	Contains a dropdown list with pre-configured settings for common radio's the VDC-850 might interface with. We found the all the preconfigured settings needed adjustments before they would pass data correctly.
VDC Built-In Test:		
	Run BIT:	Button function which runs the Built-In-Test of the connected VDC hardware.

Setup for the PRC-6809 (Non-CCI PRC-148) Radio

ViaSat eMail - Setup / VDC Configuration

VDC Configuration MIL 188–184 TAB

	Field / Category:	Setting / Value Used:
Compliance:		STRICT 184 COMPLAINCE UNAVAILABLE
Compliance (Carrier Sense Multiple Access):		
	CSMA Enabled:	Enabled
	Probe Retries:	4
ARQ (Automatic Repeat Acks):		
	ARQ Enabled (Receiver Acks):	Enabled
	Burst Retries:	8
Burst Configuration:		
	Legacy Protocol MAX PACKETS:	170
	Enhanced Protocol MAX PACKETS:	1024
Forward Error Correction:		
	FEC Code Rate:	1
	Adaptive:	Enabled
Compression:		
	VDC Data Compression Enabled:	Enabled

Setup for the PRC-6809 (Non-CCI PRC-148) Radio

ViaSat eMail - Setup / VDC Configuration

VDC Configuration Delays TAB

	Field / Category:	Setting / Value Used:
Channel Access Delays:		
	Channel Access Speed:	**Fast**
Acknowledgement Delays:		
	Additional ACK Delays:	**4**
	Turn Around Delay:	**2**
Data Padding:		
	Transmit Start Delay:	**4**
	Transmit End Delay:	**2**
AN/PSC-5 Parameters:		
	CTS Tx Clock Timeout:	**4**
	RTS Off to On Delay:	**2**

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APPENDIX E. COMMUNICATION LOGS FROM PRE-EVALUATION AND EVALUATION.

The communication logs gathered during the pre-evaluation and evaluation phases of the study are found below. Vehicle 1 is represented with a local address of 5 and Vehicle 2 is represented with a local address of 10. The time setting for Vehicle 2 is approximately a half minute to the right of the Vehicle 1 time setting. As such, there are instances where Vehicle 1 successfully receives a message from Vehicle 2 prior to the time Vehicle 2 transmitted the message.

Local Addres#	Time Stamp	Description	Status	Address
5	42572.42078	VDC Firmware Version: '#U86695 8.2.02 11/07/2014 3:07PM PDT'		
5	42572.42078	VDC Hardware Version: '9.8.3.2'		
5	42572.42082	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.42083	VDC Firmware Version: '#U86685 8.2.02 11/07/2014 3:07PM PDT'		
10	42572.42083	VDC Hardware Version: '9.8.3.2'		
10	42572.42088	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.43177	VDC Firmware Version: '#U86685 8.2.02 11/07/2014 3:07PM PDT'		
10	42572.43177	VDC Hardware Version: '9.8.3.2'		
5	42572.43178	VDC Firmware Version: '#U86695 8.2.02 11/07/2014 3:07PM PDT'		
5	4257	VDC Hardware Version: '9.8.3.2'		

Local Addr es#	Time Sta mp	Description	Status	Address
	2.43 178			
10	4257 2.43 182	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	4257 2.43 183	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	4257 2.43 207	“Hello from right side (10) via Broadcast”	Rx Success	Right side 5 local <5>
10	4257 2.43 216	“Hello from right side (10) via Broadcast”	Sent Successfully	Broadca st
5	4257 2.43 257	“Hello. Ack Note sent from Right Laptop. “	Sent Successfully	Broadca st
5	4257 2.43 295	“Test”	Sent Successfully	Broadca st
10	4257 2.43 303	“Test”	Rx Success	Left side 10 local <10>
5	4257 2.43 319	“Hello. Ack Note sent from Right Laptop. “	Sent Successfully	Broadca st
10	4257 2.43 328	“Hello. Ack Note sent from Right Laptop. “	Rx Success	Left side 10 local <10>
5	4257 2.43 344	“Hello. Ack Note sent from Right Laptop. “	Sent Successfully	Broadca st
10	4257 2.43 353	“Hello. Ack Note sent from Right Laptop. “	Rx Success	Left side 10 local <10>
5	4257 2.43 377	“Testing for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkd shflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdj...”	Rx Success	Right side 5 local <5>
10	4257 2.43 387	“Testing for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkd shflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdj...”	Sent Successfully	Broadca st
5	4257	“Testing for fragment size.	Rx Success	Right

Local Addres#	Time Stamp	Description	Status	Address
	2.434	lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdj...”		side 5 local <5>
10	42572.43409	“Testing for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdj...”	Sent Successfully	Broadcast
5	42572.43414	“Testing for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdj...”	Rx Success	Right side 5 local <5>
5	42572.4342	“e. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting fo...”	Rx Success	Right side 5 local <5>
10	42572.43424	“Testing for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdj...”	Sent Successfully	Broadcast
5	42572.43424	“kjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;l...”	Rx Success	Right side 5 local <5>
10	42572.43428	“e. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting fo...”	Sent Successfully	Broadcast
10	42572.43433	“kjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;l...”	Sent Successfully	Broadcast
5	42572.43479	“Testing for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdj...”	Rx Success	Right side 5 local <5>
10	42572.43488	“Testing for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdj...”	Sent Successfully	Broadcast
5	42572.43491	“Testing for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdj...”	Rx Success	Right side 5 local <5>
5	42572.43494	“e. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjf”	Rx Success	Right side 5 local <5>
10	4257	“Testing for fragment size.	Sent	Broadca

Local Addres#	Time Stamp	Description	Status	Address
	2.435	lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdj...”	Successfully	st
10	42572.43503	“e. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjf”	Sent Successfully	Broadcast
5	42572.43586	“Testing for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdj...”	Sent Successfully	Broadcast
5	42572.43588	“ Testing for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalk...”	Sent Successfully	Broadcast
10	42572.43595	“Testing for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdj...”	Rx Success	Left side 10 local <10>
10	42572.43597	“ Testing for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalk...”	Rx Success	Left side 10 local <10>
5	42572.4365	“Testing for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdj...”	Rx Success	Right side 5 local <5>
5	42572.43656	“aslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskj...”	Rx Success	Right side 5 local <5>
10	42572.43659	“Testing for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdj...”	Sent Successfully	Broadcast
10	42572.43666	“aslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskj...”	Sent Successfully	Broadcast
5	42572.4369	“aslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskj...”	Sent Successfully	Broadcast
5	42572.43693	“ fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhds...”	Sent Successfully	Broadcast
10	42572.43699	“aslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskj...”	Rx Success	Left side 10 local <10>
10	4257	“ fragment size.	Rx Success	Left side

Local Addres#	Time Stamp	Description	Status	Address
	2.43 701	lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkd shflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdjfhsadkjf hds...”		10 local <10>
5	4257 2.43 714	“aslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhd skjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskj...”	Rx Success	Right side 5 local <5>
5	4257 2.43 72	“shflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdjfhsadkj fhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfasl...”	Rx Success	Right side 5 local <5>
10	4257 2.43 722	“aslkdjfhsdkjfhlkdshflkjdhfkjdhlkdsjhflkjdhflkdsjfhd skjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskj...”	Sent Successfully	Broadcast
5	4257 2.43 726	“shflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdjfhsadkj fhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfasl...”	Rx Success	Right side 5 local <5>
10	4257 2.43 729	“shflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdjfhsadkj fhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfasl...”	Sent Successfully	Broadcast
5	4257 2.43 733	“jhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkd shf...”	Rx Success	Right side 5 local <5>
10	4257 2.43 734	“shflkjdhfkjdhlkdsjhflkjdhflkdsjfhdskjfhalkdjfhsadkj fhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfasl...”	Sent Successfully	Broadcast
10	4257 2.43 742	“jhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkd shf...”	Sent Successfully	Broadcast
5	4257 2.43 772	“jhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkd shf...”	Rx Success	Right side 5 local <5>
10	4257 2.43 784	“jhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkd shf...”	Sent Successfully	Left side 10 local <10>
5	4257 2.43 831	“jhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkd shf...”	Sent Successfully	Right side 5 local <5>

Local Addres#	Time Stamp	Description	Status	Address
10	42572.43836	“jhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshf...”	Rx Success	Left side 10 local <10>
5	42572.43855	“jhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshf...”	Sent Successfully	Right side 5 local <5>
10	42572.43861	“jhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshf...”	Rx Success	Left side 10 local <10>
5	42572.43878	“jhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshf...”	Rx Success	Right side 5 local <5>
10	42572.4389	“jhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshf...”	Sent Successfully	Left side 10 local <10>
5	42572.47939	VDC Firmware Version: ‘#U86695 8.2.02 11/07/2014 3:07PM PDT’		
5	42572.47939	VDC Hardware Version: ‘9.8.3.2’		
5	42572.47939	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	42572.47962	VDC Firmware Version: ‘#U86695 8.2.02 11/07/2014 3:07PM PDT’		
5	42572.47963	VDC Hardware Version: ‘9.8.3.2’		
5	42572.47968	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.4806	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.4806	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		

Local Addres#	Time Stamp	Description	Status	Address
10	42572.4806	VDC Hardware Version: ‘9.8.3.2’		
10	42572.4806	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.48074	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.48074	VDC Hardware Version: ‘9.8.3.2’		
10	42572.48079	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	42572.4809	“jhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshf...”	Rx Success	Right side 5 local <5>
10	42572.48102	“jhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshf...”	Sent Successfully	Left side 10 local <10>
5	42572.48164	“jhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshf...”	Sent Successfully	Right side 5 local <5>
10	42572.48169	“jhflkjdhflkdsjfhdskjfhalkdjfhsadkjfhdskjfTesting for fragment size. lkjfa;lkdsjfkffskjfhskjfhkdsjfhdslkhfaslkdjfhsdkjfhlkdshf...”	Rx Success	Left side 10 local <10>
5	42572.48237	“Base station to remote in paking lot direct test”	Rx Success	Right side 5 local <5>
10	42572.48249	“Base station to remote in paking lot direct test”	Sent Successfully	Left side 10 local <10>
5	42572.4828	“Remote station to remote in paking lot direct test”	Sent Successfully	Right side 5 local <5>
10	42572.48	“Remote station to remote in paking lot direct test”	Rx Success	Left side 10 local

Local Addres#	Time Stamp	Description	Status	Address
	286			<10>
5	42572.4852	“Phone Numbers for contacts”	Rx Success	Right side 5 local <5>
10	42572.48531	“Phone Numbers for contacts”	Sent Successfully	Left side 10 local <10>
10	42572.48587	“RE: Phone Numbers for contacts”	Rx Success	Left side 10 local <10>
5	42572.48608	“RE: Phone Numbers for contacts”	Sent Successfully	Right side 5 local <5>
5	42572.4865	“RE [2]: Phone Numbers for contacts”	Rx Success	Right side 5 local <5>
10	42572.48662	“RE [2]: Phone Numbers for contacts”	Sent Successfully	Left side 10 local <10>
5	42572.49037	“Screenshot”	Aborted - No Acknowledgement	Right side 5 local <5>
10	42572.49159	“Screenshot”	Rx Failure: Message Truncated	Left side 10 local <10>
5	42572.49302	“Screenshot”	Sent Successfully	Right side 5 local <5>
10	42572.49307	“Screenshot”	Rx Success	Left side 10 local <10>
5	42572.49426	“Broadcast testing with small data”	Rx Success	Right side 5 local <5>
10	42572.49435	“Broadcast testing with small data”	Sent Successfully	Broadcast

Local Addres#	Time Stamp	Description	Status	Address
5	42572.49458	“Broadcast testing with small data”	Sent Successfully	Broadcast
10	42572.49466	“Broadcast testing with small data”	Rx Success	Left side 10 local <10>
10	42572.49493	“Broadcast testing with small dataBroadcast testing with small dataBroadcast testing with small dataBroadcast testing with sma...”	Sent Successfully	Broadcast
5	42572.49524	“Broadcast testing with small dataBroadcast testing with small dataBroadcast testing with small dataBroadcast testing with sma...”	Rx Success	Right side 5 local <5>
10	42572.49534	“Broadcast testing with small dataBroadcast testing with small dataBroadcast testing with small dataBroadcast testing with sma...”	Sent Successfully	Broadcast
5	42572.49549	“Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data Broadcast testing wi...”	Sent Successfully	Broadcast
10	42572.49557	“Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data Broadcast testing wi...”	Rx Success	Left side 10 local <10>
5	42572.49568	“ith small data Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data Broa...”	Rx Success	Right side 5 local <5>
10	42572.49572	“Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data Broadcast testing wi...”	Sent Successfully	Broadcast
10	42572.49576	“ith small data Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data Broa...”	Sent Successfully	Broadcast
5	42572.49595	“Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data Broadcast testing wi...”	Rx Success	Right side 5 local <5>
10	42572.49604	“Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data Broadcast testing wi...”	Sent Successfully	Broadcast
5	42572.4961	“Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data	Rx Success	Right side 5 local

Local Addres#	Time Stamp	Description	Status	Address
		Broadcast testing wi...”		<5>
5	42572.49615	“ith small data Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data Broa...”	Rx Success	Right side 5 local <5>
10	42572.49618	“Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data Broadcast testing wi...”	Sent Successfully	Broadcast
10	42572.49624	“ith small data Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data Broa...”	Sent Successfully	Broadcast
5	42572.49637	“Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data Broadcast testing wi...”	Sent Successfully	Broadcast
5	42572.4964	“Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data Broadcast testing wi...”	Sent Successfully	Broadcast
10	42572.49646	“Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data Broadcast testing wi...”	Rx Success	Left side 10 local <10>
10	42572.49648	“Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data Broadcast testing wi...”	Rx Success	Left side 10 local <10>
5	42572.49669	“Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data Broadcast testing wi...”	Sent Successfully	Broadcast
5	42572.49671	“Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data Broadcast testing wi...”	Sent Successfully	Broadcast
10	42572.49677	“Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data Broadcast Øfž†ú „g ...”	Rx Success	Left side 10 local <10>
10	42572.49679	“Broadcast testing with small data Broadcast testing with small data Broadcast testing with small data Broadcast testing wi...”	Rx Success	Left side 10 local <10>
5	42572.50013	C:\Program Files\ViaSat\Vmail\Rx\VDC MI~1.png	Rx Failure: Message Truncated	Right side 5 local <5>

Local Address#	Time Stamp	Description	Status	Address
10	42572.50051	C:\Users\user\Desktop\VDC MIL 188–184 this was via mail send in paking lot.png	Sent Successfully	Broadcast
10	42572.50153	C:\Users\user\Desktop\VDC MIL 188–184 this was via mail send in paking lot.png	Aborted - By Operator	Broadcast
5	42572.50318	C:\Program Files\ViaSat\Vmail\Rx\VDC 2.png	Rx Success	Right side 5 local <5>
10	42572.5033	C:\Users\user\Desktop\VDC MIL 188–184 this was via mail send in paking lot.png	Sent Successfully	Left side 10 local <10>
5	42572.50811	C:\Program Files\ViaSat\Vmail\Rx\VDC 2.png	Aborted - No VDC	Right side 5 local <5>
5	42572.50848	VDC Hardware Version: ‘0.0.2.7’		
5	42572.50848	VDC Firmware Version: ‘#U86695 8.2.02 11/07/2014 3:07PM PDT’		
5	42572.50848	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	42572.50848	VDC Hardware Version: ‘9.8.3.2’		
5	42572.50853	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	42572.50875	VDC Firmware Version: ‘#U86695 8.2.02 11/07/2014 3:07PM PDT’		
5	42572.50875	VDC Hardware Version: ‘9.8.3.2’		
5	42572.5088	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.50896	C:\Program Files\ViaSat\Vmail\Rx\VDC 2.png	Rx Failure: Message Truncated	Left side 10 local <10>

Local Addres#	Time Stamp	Description	Status	Address
5	42572.51234	C:\Program Files\ViaSat\Vmail\Rx\VDC 2.png	Sent Successfully	Right side 5 local <5>
10	42572.51238	C:\Program Files\ViaSat\Vmail\Rx\VDC 3.png	Rx Failure: CRC Error	Left side 10 local <10>
5	42572.51424	C:\Program Files\ViaSat\Vmail\Rx\VDC 2.png	Sent Successfully	Right side 5 local <5>
10	42572.51429	C:\Program Files\ViaSat\Vmail\Rx\VDC 4.png	Rx Success	Left side 10 local <10>
10	42572.51571	VDC Firmware Version: '#U86685 8.2.02 11/07/2014 3:07PM PDT'		
10	42572.51571	VDC Hardware Version: '9.8.3.2'		
10	42572.51575	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	42572.52068	C:\Program Files\ViaSat\Vmail\Rx\VDC 2.png	Aborted - No Acknowledgement	Right side 5 local <5>
10	42572.52515	VDC Hardware Version: '0.0.4.0'		
10	42572.52515	VDC Firmware Version: '#U86685 8.2.02 11/07/2014 3:07PM PDT'		
10	42572.5252	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.5252	VDC Hardware Version: '9.8.3.2'		
10	42572.52524	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.52	VDC Firmware Version: '#U86685 8.2.02 11/07/2014 3:07PM PDT'		

Local Addres#	Time Stamp	Description	Status	Address
	532			
10	42572.52532	VDC Hardware Version: ‘9.8.3.2’		
10	42572.52537	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	42572.52549	“before in SDC lot drive test”	Rx Success	Right side 5 local <5>
10	42572.5256	“before in SDC lot drive test”	Sent Successfully	Left side 10 local <10>
5	42572.52582	“before in SDC lot drive test confirmed”	Sent Successfully	Right side 5 local <5>
10	42572.52588	“before in SDC lot drive test confirmed”	Rx Success	Left side 10 local <10>
5	42572.52652	“safe trip”	Rx Success	Right side 5 local <5>
10	42572.52663	“safe trip”	Sent Successfully	Left side 10 local <10>
5	42572.5281	“safe trip aye”	Sent Successfully	Right side 5 local <5>
10	42572.52816	“safe trip aye”	Rx Success	Left side 10 local <10>
10	42572.53102	“relay when you get on the 202. thx”	Aborted - No Acknowledgement	Left side 10 local <10>
5	42572.53359	“Radio Check”	Aborted - Channel Acquisition Timeout	Right side 5 local <5>
5	42572.53	“Radio Check”	Aborted - Channel	Right side 5

Local Addres#	Time Stamp	Description	Status	Address
	456		Acquisition Timeout	local <5>
5	42572.53558	“Two failed radio checks while driving.”	Aborted - Channel Acquisition Timeout	Right side 5 local <5>
10	42572.53672	“sending test after change 1/4 watt to 5 watts”	Aborted - Channel Acquisition Timeout	Left side 10 local <10>
10	42572.53684	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.53684	VDC Hardware Version: ‘9.8.3.2’		
10	42572.53689	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.53788	“sending 1/4 to 5 watts restet vdc”	Aborted - Channel Acquisition Timeout	Left side 10 local <10>
5	42572.53992	“Radio check w/ Mag Ant”	Aborted - Channel Acquisition Timeout	Right side 5 local <5>
10	42572.54103	“test from sdc”	Aborted - Channel Acquisition Timeout	Left side 10 local <10>
10	42572.54118	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.54118	VDC Hardware Version: ‘9.8.3.2’		
10	42572.54123	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	42572.54186	“Radio check”	Aborted - Channel Acquisition Timeout	Right side 5 local <5>

Local Address#	Time Stamp	Description	Status	Address
10	42572.54212	“sdc parking to remoye”	Sent Successfully	Broadcast
10	42572.54278	“sending as broadcast message copy?”	Sent Successfully	Broadcast
5	42572.54293	“Radio check w/ stock ant parked”	Aborted - Channel Acquisition Timeout	Right side 5 local <5>
5	42572.54339	VDC Firmware Version: ‘#U86695 8.2.02 11/07/2014 3:07PM PDT’		
5	42572.54339	VDC Hardware Version: ‘9.8.3.2’		
5	42572.54344	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.54378	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.54378	VDC Hardware Version: ‘9.8.3.2’		
10	42572.54383	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	42572.5444	“Radio Check w/ stock ant parked”	Aborted - Channel Acquisition Timeout	Right side 5 local <5>
10	42572.54498	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.54498	VDC Hardware Version: ‘9.8.3.2’		
10	42572.54502	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	42572.54566	“Radio Check. Stock Antena. Parked”	Aborted - Channel Acquisition	Right side 5 local

Local Addres#	Time Stamp	Description	Status	Address
			Timeout	<5>
5	42572.5461	“Radio Check. Stock Ant. Parked”	Sent Successfully	Broadcast
10	42572.54618	“Radio Check. Stock Ant. Parked”	Rx Success	Left side 10 local <10>
10	42572.5464	“radio chack back via broadcast”	Sent Successfully	Broadcast
10	42572.54664	“on more? “	Sent Successfully	Broadcast
10	42572.54752	“testmail”	Aborted - Channel Acquisition Timeout	Left side 10 local <10>
10	42572.54899	VDC Hardware Version: ‘0.0.2.7’		
10	42572.54899	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.549	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.549	VDC Hardware Version: ‘9.8.3.2’		
10	42572.549	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.54914	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.54914	VDC Hardware Version: ‘9.8.3.2’		
10	42572.54919	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.54933	“test”	Sent Successfully	Broadcast

Local Addres#	Time Stamp	Description	Status	Address
5	42572.54934	VDC Firmware Version: '#U86695 8.2.02 11/07/2014 3:07PM PDT'		
5	42572.54934	VDC Hardware Version: '9.8.3.2'		
5	42572.54935	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.55023	"test after reboot"	Sent Successfully	Broadcast
5	42572.55037	"Radio Check. Stock Ant. Parked"	Sent Successfully	Broadcast
10	42572.55046	"Radio Check. Stock Ant. Parked"	Rx Success	Left side 10 local <10>
10	42572.55067	"return"	Sent Successfully	Broadcast
5	42572.55154	"Radio Check. Stock Ant. Parked"	Aborted - Channel Acquisition Timeout	Right side 5 local <5>
5	42572.55176	VDC Firmware Version: '#U86695 8.2.02 11/07/2014 3:07PM PDT'		
5	42572.55176	VDC Hardware Version: '9.8.3.2'		
10	42572.55179	VDC Firmware Version: '#U86685 8.2.02 11/07/2014 3:07PM PDT'		
10	42572.55179	VDC Hardware Version: '9.8.3.2'		
5	42572.55181	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.55184	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	4257	VDC Firmware Version: '#U86695 8.2.02		

Local Address#	Time Stamp	Description	Status	Address
	2.55 289	11/07/2014 3:07PM PDT’		
5	4257 2.55 289	VDC Hardware Version: ‘9.8.3.2’		
10	4257 2.55 293	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	4257 2.55 293	VDC Hardware Version: ‘9.8.3.2’		
5	4257 2.55 294	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	4257 2.55 297	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	4257 2.55 409	“hjghjghjghjg”	Aborted - Channel Acquisition Timeout	Left side 10 local <10>
10	4257 2.55 44	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	4257 2.55 44	VDC Hardware Version: ‘9.8.3.2’		
10	4257 2.55 444	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	4257 2.55 447	VDC Firmware Version: ‘#U86695 8.2.02 11/07/2014 3:07PM PDT’		
5	4257 2.55 448	VDC Hardware Version: ‘9.8.3.2’		
5	4257 2.55 453	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	4257 2.55 514	VDC Firmware Version: ‘#U86695 8.2.02 11/07/2014 3:07PM PDT’		
5	4257 2.55	VDC Hardware Version: ‘9.8.3.2’		

Local Addres#	Time Stamp	Description	Status	Address
	514			
5	42572.55519	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.55542	“hjghjg”	Aborted - No VDC	Left side 10 local <10>
10	42572.55553	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.55553	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.55553	VDC Hardware Version: ‘9.8.3.2’		
10	42572.55558	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	42572.55558	“Broadcast Test”	Sent Successfully	Broadcast
10	42572.55566	“Broadcast Test”	Rx Success	Left side 10 local <10>
10	42572.55569	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.55569	VDC Hardware Version: ‘9.8.3.2’		
10	42572.55574	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.55617	“hjghjg”	Aborted - No VDC	Broadcast
10	42572.55627	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.55632	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		

Local Addres#	Time Stamp	Description	Status	Address
10	42572.55632	VDC Hardware Version: ‘9.8.3.2’		
10	42572.55637	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.55642	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.55642	VDC Hardware Version: ‘9.8.3.2’		
10	42572.55647	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.55677	“test broad”	Aborted - By Operator	Broadcast
5	42572.55681	“Rate Normal. Increased Delays. Compression Off”	Sent Successfully	Broadcast
10	42572.55689	“Rate Normal. Increased Delays. Compression Off”	Rx Success	Left side 10 local <10>
10	42572.55755	“test”	Sent Successfully	Broadcast
10	42572.55777	“test2”	Sent Successfully	Broadcast
10	42572.55786	“test3”	Sent Successfully	Broadcast
10	42572.55801	“test4”	Sent Successfully	Broadcast
5	42572.55884	“Test after fall”	Sent Successfully	Broadcast
10	42572.55892	“Test after fall”	Rx Success	Left side 10 local <10>
10	42572.55	“test”	Aborted - By Operator	Left side 10 local

Local Addr es#	Time Sta mp	Description	Status	Address
	939			<10>
10	4257 2.55 94	“test after test afll”	Sent Successfully	Broadca st
10	4257 2.56 019	“;lsakd;laskd”	Sent Successfully	Broadca st
10	4257 2.56	“lkjsadlksjd”	Sent Successfully	Broadca st
5	4257 2.56 015	“CAS Normal. ACK Delay 2. Turn Around Delay 1. Transmit Start 1.5 Transmit End 1 CTS TX Clock 2 RTS Off 0”	Sent Successfully	Broadca st
10	4257 2.56 023	“CAS Normal. ACK Delay 2. Turn Around Delay 1. Transmit Start 1.5 Transmit Enl 1 CTS TX Clock 2 RTS Off 0”	Rx Success	Left side 10 local <10>
10	4257 2.56 046	“CAS Normal. ACK Delay 2. Turn Around Delay 1. Transmit Start 1.5 Transmit Enl 1 CTS TX Clock 2 RTS Off 0 “	Sent Successfully	Broadca st
10	4257 2.56 161	“CAS Normal. ACK Delay 2. Turn Around Delay 1. Transmit Start 1.5 Transmit Enl 1 CTS TX Clock 2 RTS Off 0 “	Aborted - Channel Acquisition Timeout	Left side 10 local <10>
5	4257 2.56 177	“Another Test Message”	Sent Successfully	Broadca st
10	4257 2.56 186	“Another Test Message”	Rx Success	Left side 10 local <10>
10	4257 2.56 219	“CAS Normal. ACK Delay 2. Turn Around Delay 1. Transmit Start 1.5 Transmit Enl 1 CTS TX Clock 2 RTS Off 0 “	Aborted - By Operator	Left side 10 local <10>
5	4257 2.56 248	“Email Broadcast Direct”	Sent Successfully	Broadca st
10	4257 2.56 256	“Email Broadcast Direct”	Rx Success	Left side 10 local <10>
10	4257 2.56 25	“broad”	Sent Successfully	Broadca st
5	4257 2.56 359	“Direct Email Test”	Aborted - Channel Acquisition Timeout	Right side 5 local <5>

Local Addres#	Time Stamp	Description	Status	Address
10	42572.56413	"CAS Normal. ACK Delay 2. Turn Around Delay 1. Transmit Start 1.5 Transmit Enl 1 CTS TX Clock 2 RTS Off 0 "	Sent Successfully	Broadcast
10	42572.56478	"jfufdau"	Sent Successfully	Broadcast
10	42572.56528	"test"	Sent Successfully	Broadcast
5	42572.5653	"Radio Check Mag Ant Parked"	Sent Successfully	Broadcast
10	42572.56538	"Radio Check Mag Ant Parked"	Rx Success	Left side 10 local <10>
10	42572.56593	VDC Firmware Version: '#U86685 8.2.02 11/07/2014 3:07PM PDT'		
10	42572.56593	VDC Hardware Version: '9.8.3.2'		
10	42572.56597	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	42572.56644	"Radio Check Mag Ant Highway"	Sent Successfully	Broadcast
10	42572.56685	VDC Firmware Version: '#U86685 8.2.02 11/07/2014 3:07PM PDT'		
10	42572.56685	VDC Hardware Version: '9.8.3.2'		
10	42572.5669	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.56705	"8999"	Aborted - No VDC	Broadcast
10	42572.56715	VDC Firmware Version: '#U86685 8.2.02 11/07/2014 3:07PM PDT'		
10	42572.56	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		

Local Addr es#	Time Sta mp	Description	Status	Address
	72			
10	4257 2.56 72	VDC Hardware Version: ‘9.8.3.2’		
10	4257 2.56 725	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	4257 2.56 733	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	4257 2.56 733	VDC Hardware Version: ‘9.8.3.2’		
10	4257 2.56 737	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	4257 2.56 763	“Radio Check Mag Ant Highway 2”	Sent Successfully	Broadca st
10	4257 2.56 771	“Radio Check Mag Ant Highway 2”	Rx Success	Left side 10 local <10>
10	4257 2.56 775	“tterdds”	Sent Successfully	Broadca st
10	4257 2.56 801	“jjuu”	Sent Successfully	Broadca st
10	4257 2.56 841	“hhyyy”	Sent Successfully	Broadca st
10	4257 2.56 889	“ihihiih”	Sent Successfully	Broadca st
5	4257 2.57 005	“Radio Check Mag Ant Highway 3”	Sent Successfully	Broadca st
10	4257 2.57 013	“Radio Check Mag Ant Highway 3”	Rx Success	Left side 10 local <10>
10	4257 2.57 038	“jjuuu”	Sent Successfully	Broadca st

Local Addres#	Time Stamp	Description	Status	Address
5	42572.57115	“Radio CHeck Mag Ant Highway Last”	Sent Successfully	Broadcast
10	42572.5722	VDC Hardware Version: ‘0.0.2.7’		
10	42572.5722	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.5722	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.5722	VDC Hardware Version: ‘9.8.3.2’		
10	42572.5722	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.57237	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.57237	VDC Hardware Version: ‘9.8.3.2’		
10	42572.57242	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.57295	“test broad?”	Aborted - No VDC	Broadcast
10	42572.57339	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.57339	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.57339	VDC Hardware Version: ‘9.8.3.2’		
10	42572.57344	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.57	“broadcast”	Aborted - By Operator	Broadcast

Local Addres#	Time Stamp	Description	Status	Address
	374			
10	42572.57383	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.57383	VDC Hardware Version: ‘9.8.3.2’		
10	42572.57388	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.57427	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.57427	VDC Hardware Version: ‘9.8.3.2’		
10	42572.57432	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.57446	“broad”	Sent Successfully	Broadcast
10	42572.57464	“you receving this broadcast?”	Sent Successfully	Broadcast
10	42572.57531	“direct to you”	Aborted - Channel Acquisition Timeout	Left side 10 local <10>
10	42572.57544	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.57544	VDC Hardware Version: ‘9.8.3.2’		
10	42572.57549	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	42572.57735	“test”	Rx Success	Right side 5 local <5>
10	42572.57	“test”	Sent Successfully	Left side 10 local

Local Address#	Time Stamp	Description	Status	Address
	748			<10>
5	42572.57765	“Rcvd test mail”	Sent Successfully	Broadcast
10	42572.57772	“Rcvd test mail”	Rx Success	Left side 10 local <10>
5	42572.57788	“once via”	Rx Success	Right side 5 local <5>
10	42572.57802	“once via”	Sent Successfully	Left side 10 local <10>
5	42572.57821	“where are u at?”	Rx Success	Right side 5 local <5>
10	42572.57833	“where are u at?”	Sent Successfully	Left side 10 local <10>
5	42572.57834	“around the corner”	Sent Successfully	Broadcast
10	42572.57843	“around the corner”	Rx Success	Left side 10 local <10>
5	42572.5785	“at on ramp when rcvd first”	Sent Successfully	Broadcast
10	42572.57856	“at on ramp when rcvd first”	Rx Success	Left side 10 local <10>
5	42572.58201	“Heading West will send periodic exit numbers”	Sent Successfully	Broadcast
10	42572.58209	“Heading West will send periodic exit numbers”	Rx Success	Left side 10 local <10>
5	42572.58355	“Road test 1: Right to left”	Rx Success	Right side 5 local <5>

Local Addres#	Time Stamp	Description	Status	Address
10	42572.58369	“Road test 1: Right to left”	Sent Successfully	Left side 10 local <10>
5	42572.58422	“Road test 2: right to left”	Rx Success	Right side 5 local <5>
10	42572.58435	“Road test 2: right to left”	Sent Successfully	Left side 10 local <10>
5	42572.58438	“Ack Test 1 and Test 2”	Sent Successfully	Broadcast
10	42572.58446	“Ack Test 1 and Test 2”	Rx Success	Left side 10 local <10>
5	42572.58517	“Road test 3: Right to left”	Rx Success	Right side 5 local <5>
10	42572.58547	“Road test 3: Right to left”	Sent Successfully	Left side 10 local <10>
5	42572.58556	“Road Test 3 L&C”	Sent Successfully	Broadcast
5	42572.58627	“road test 4: Righyt to left”	Rx Success	Right side 5 local <5>
10	42572.58641	“road test 4: Righyt to left”	Sent Successfully	Left side 10 local <10>
5	42572.58641	“Ok 202 West”	Sent Successfully	Broadcast
10	42572.58649	“Ok 202 West”	Rx Success	Left side 10 local <10>
5	42572.587	“Road test 5: right to left”	Rx Success	Right side 5 local <5>
10	4257	“Road test 5: right to left”	Sent	Left side

Local Address#	Time Stamp	Description	Status	Address
	2.58713		Successfully	10 local <10>
5	42572.58719	“Are you going to take trhe 10”	Rx Success	Right side 5 local <5>
10	42572.58733	“Are you going to take trhe 10”	Sent Successfully	Left side 10 local <10>
5	42572.58745	“Road Test 5 Ack. Affirmative on taking 10”	Sent Successfully	Broadcast
10	42572.58753	“Road Test 5 Ack. Affirmative on taking 10”	Rx Success	Left side 10 local <10>
5	42572.58794	“copy all... Heading to 101 north”	Rx Success	Right side 5 local <5>
10	42572.58807	“copy all... Heading to 101 north”	Sent Successfully	Left side 10 local <10>
5	42572.58867	“On loop to 10E now”	Sent Successfully	Broadcast
5	42572.58882	“No 10 West”	Sent Successfully	Broadcast
5	42572.5897	“Request direct test”	Sent Successfully	Broadcast
10	42572.59324	“Road test 6: conservative to liberal”	Aborted - No Acknowledgement	Left side 10 local <10>
5	42572.59332	“Passing exit 153B. Getting bursts and acks. No msg”	Sent Successfully	Broadcast
10	42572.59414	VDC Hardware Version: ‘0.0.0.0’		
10	42572.59414	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	4257	VDC Capabilities: Legacy Protocol, Enhanced		

Local Addres#	Time Stamp	Description	Status	Address
	2.59 414	Protocol, Quadruple Max Packets		
10	4257 2.59 414	VDC Hardware Version: ‘9.8.3.2’		
10	4257 2.59 419	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	4257 2.59 5	“Got off on Broadway Road. Due to traffic. Not rcv anything.”	Sent Successfully	Broadcast
10	4257 2.59 507	“Test 6: failed”	Aborted - No VDC	Left side 10 local <10>
10	4257 2.59 507	“Test 7: right to left”	Aborted - No VDC	Left side 10 local <10>
10	4257 2.59 63	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	4257 2.59 63	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	4257 2.59 63	VDC Hardware Version: ‘9.8.3.2’		
10	4257 2.59 63	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	4257 2.59 679	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	4257 2.59 679	VDC Hardware Version: ‘9.8.3.2’		
10	4257 2.59 684	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	4257 2.59 958	“Test 7: Jason went for BBQ”	Rx Success	Right side 5 local <5>
10	4257 2.59	“Test 7: Jason went for BBQ”	Sent Successfully	Left side 10 local

Local Addres#	Time Stamp	Description	Status	Address
	972			<10>
5	42572.59991	“Rgr. Jason for BBQ Aye”	Sent Successfully	Broadcast
10	42572.59999	“Rgr. Jason for BBQ Aye”	Rx Success	Left side 10 local <10>
5	42572.60006	“Prince: Awesome that”	Sent Successfully	Broadcast
10	42572.60014	“Prince: Awesome that”	Rx Success	Left side 10 local <10>
5	42572.60068	“Road Test 8” Right @ McKeleps 101”	Rx Success	Right side 5 local <5>
10	42572.60082	“Road Test 8” Right @ McKeleps 101”	Sent Successfully	Left side 10 local <10>
5	42572.60108	“Where to try next? Back east?”	Sent Successfully	Broadcast
10	42572.60117	“Where to try next? Back east?”	Rx Success	Left side 10 local <10>
5	42572.60131	“Curently @ Frontage & 55th”	Sent Successfully	Broadcast
10	42572.6014	“Curently @ Frontage & 55th”	Rx Success	Left side 10 local <10>
10	42572.60248	“do you have compression setting on?”	Aborted - Channel Acquisition Timeout	Left side 10 local <10>
10	42572.60253	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.60253	VDC Hardware Version: ‘9.8.3.2’		
10	42572.60	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		

Local Address#	Time Stamp	Description	Status	Address
	258			
5	42572.60295	“Good copy?”	Sent Successfully	Broadcast
10	42572.60303	“Good copy?”	Rx Success	Left side 10 local <10>
5	42572.60407	“Request repeat on last msg rcvd”	Aborted - Channel Acquisition Timeout	Right side 5 local <5>
5	42572.60461	VDC Firmware Version: ‘#U86695 8.2.02 11/07/2014 3:07PM PDT’		
5	42572.60462	VDC Hardware Version: ‘9.8.3.2’		
5	42572.60466	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.60484	“you call how about a few static tests?”	Aborted - Channel Acquisition Timeout	Left side 10 local <10>
5	42572.60559	VDC Firmware Version: ‘#U86695 8.2.02 11/07/2014 3:07PM PDT’		
5	42572.60559	VDC Hardware Version: ‘9.8.3.2’		
5	42572.60564	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.60566	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.60566	VDC Hardware Version: ‘9.8.3.2’		
10	42572.60571	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.60	“copy?”	Aborted - No VDC	Left side 10 local

Local Address#	Time Stamp	Description	Status	Address
	589			<10>
10	42572.606	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.60604	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.60604	VDC Hardware Version: ‘9.8.3.2’		
10	42572.60609	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.60683	“test out”	Aborted - By Operator	Left side 10 local <10>
5	42572.60767	“direct test”	Aborted - Channel Acquisition Timeout	Right side 5 local <5>
10	42572.60771	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.60771	VDC Hardware Version: ‘9.8.3.2’		
10	42572.60775	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.60814	“test out”	Aborted - By Operator	Left side 10 local <10>
10	42572.60823	“broadcast”	Sent Successfully	Broadcast
10	42572.60868	“12121”	Sent Successfully	Broadcast
10	42572.60878	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.60878	VDC Hardware Version: ‘9.8.3.2’		

Local Address#	Time Stamp	Description	Status	Address
10	42572.60883	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	42572.60899	“broadcast test”	Sent Successfully	Broadcast
10	42572.60907	“broadcast test”	Rx Success	Left side 10 local <10>
10	42572.60931	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.60931	VDC Hardware Version: ‘9.8.3.2’		
10	42572.60935	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	42572.60977	VDC Firmware Version: ‘#U86695 8.2.02 11/07/2014 3:07PM PDT’		
5	42572.60977	VDC Hardware Version: ‘9.8.3.2’		
5	42572.60981	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.60997	“broadcast”	Sent Successfully	Broadcast
5	42572.60997	“broadcast test. compression on”	Sent Successfully	Broadcast
10	42572.61005	“broadcast test. compression on”	Rx Success	Left side 10 local <10>
10	42572.6103	“asasa”	Sent Successfully	Broadcast
10	42572.61098	“direct”	Aborted - Channel Acquisition Timeout	Left side 10 local <10>
10	4257	“sadsadsad”	Aborted - By	Left side

Local Addr es#	Time Sta mp	Description	Status	Address
	2.61 154 4257		Operator	10 local <10> Left side
10	2.61 222 4257	“asasa”	Aborted - By Operator	10 local <10>
10	2.61 229 4257	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	2.61 229 4257	VDC Hardware Version: ‘9.8.3.2’		
10	2.61 234 4257	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	2.61 272 4257	“broadcast”	Aborted - By Operator	Broadca st
10	2.61 282 4257	“asas”	Sent Successfully	Broadca st
5	2.61 309 4257	“broadcast test”	Sent Successfully	Broadca st Left side
10	2.61 318 4257	“broadcast test”	Rx Success	10 local <10>
10	2.61 353 4257	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	2.61 353 4257	VDC Hardware Version: ‘9.8.3.2’		
10	2.61 358 4257	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	2.61 373 4257	“asasasa”	Sent Successfully	Broadca st
10	2.61 396 4257	“dsadsadsadsads”	Sent Successfully	Broadca st
10	2.61 459	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		

Local Addr es#	Time Sta mp	Description	Status	Address
10	4257 2.61 459	VDC Hardware Version: ‘9.8.3.2’		
10	4257 2.61 464	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	4257 2.61 48	“sadsadsadsad”	Sent Successfully	Broadca st
10	4257 2.61 556	“direct? “	Aborted - Channel Acquisition Timeout	Left side 10 local <10>
5	4257 2.61 564	VDC Firmware Version: ‘#U86695 8.2.02 11/07/2014 3:07PM PDT’		
5	4257 2.61 564	VDC Hardware Version: ‘9.8.3.2’		
5	4257 2.61 568	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	4257 2.61 573	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	4257 2.61 574	VDC Hardware Version: ‘9.8.3.2’		
10	4257 2.61 579	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
5	4257 2.61 653	“hearing not seeing”	Sent Successfully	Broadca st
10	4257 2.61 661	“hearing not seeing”	Rx Success	Left side 10 local <10>
10	4257 2.61 66	“sadsadsadsd”	Aborted - By Operator	Left side 10 local <10>
10	4257 2.61 734	“copy that!”	Aborted - Channel Acquisition Timeout	Left side 10 local <10>

Local Address#	Time Stamp	Description	Status	Address
10	42572.61741	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.61741	VDC Hardware Version: ‘9.8.3.2’		
10	42572.61745	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.61808	“fast”	Aborted - By Operator	Left side 10 local <10>
10	42572.61815	VDC Firmware Version: ‘#U86685 8.2.02 11/07/2014 3:07PM PDT’		
10	42572.61815	VDC Hardware Version: ‘9.8.3.2’		
10	42572.61821	VDC Capabilities: Legacy Protocol, Enhanced Protocol, Quadruple Max Packets		
10	42572.6191	“heading back?”	Aborted - By Operator	Left side 10 local <10>
10	42572.61921	“broad”	Sent Successfully	Broadcast

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